ERODIBILITY OF SELECTED HAWAII SOILS BY RAINFALL SIMULATION

ARS W-35
May 1976

WESTERN REGION

AGRICULTURAL RESEARCH SERVICE • U.S. DEPARTMENT OF AGRICULTURE

ABSTRACT

Sediment losses were determined under simulated rainstorms for 10 soil series representing four orders on the island of Oahu and two on Hawaii. Two successive rainstorms were generally applied, the first (dry run) at prevailing field moisture conditions and the second (wet run) after nearly 18 hours from the first storm. Each had an approximate intensity of 2.5 in/hr and a duration of 120 minutes. Soil loss data were used to calculate erodibilities (*K* values) from dry and wet runs for various increments within each storm and for several soil surface preparations.

Erodibilities for cultivated sites on Oahu generally increased during successive intervals of the dry runs. The erodibilities appeared to reach constant values only during latter intervals of the wet runs. Thus, wet runs yielded higher *K* values (0.001 to 0.41) than did the dry runs (0 to 0.26). This was attributed to faster runoff initiation, which was in turn dependent upon soil-water saturation deficit, and to gradual weakening of soil aggregates after wetting. Construction sites and plantation roads generally exhibited higher erodibilities than agricultural sites.

Differences between dry and wet runs were found on only two of the five volcanic ash soils studied on the island of Hawaii. Erodibilities for their soils were 0.08 to 0.60 for dry runs and 0.07 to 0.51 for wet runs.

KEYWORDS: Soil erosion, Soil conservation, Sediment loss, Rainfall-runoff hydrology, Tropical soils, Universal soil loss equation.

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE
In Cooperation With
University of Hawaii Agricultural Experiment Station

ACKNOWLEDGMENTS

A number of individuals and organizations have helped in a meaningful way during this study. The authors gratefully acknowledge W. W. Wischmeier, Agricultural Research Service (ARS), U.S. Department of Agriculture (USDA), for his valuable suggestions and assistance during the planning and analysis phases of the study.

Appreciation is extended to the following members of the Soil Conservation Service, USDA: S. Nakamura for assistance with site selections on the island of Oahu, M. Coray and M. Tulang for site selections on the island of Hawaii, and O. F. Bailey and S. Nakamura for soil description and classification of the soils on each site.

Grateful acknowledgment is due the following organizations for granting permission to conduct rainfall simulation tests on their land: on the island of Oahu--Hawaiian Sugar Planters' Association, Dole Company, Oahu Sugar Company, Del Monte Corporation, United States Naval Transmitting Facility at Lualualei, Kamiyama Farm, and Kamiya Farm; and on the island of Hawaii--Hamakua Mill Company, Hawaiian Sugar Company, Hawaiian Homes Land, Ka'u Sugar Company, and Hawaiian Ranch Company.

The following personnel ably participated in conducting tests with the rainfall simulator: A. Dooley, R. Montgomry, and A. Smith of ARS; and T. R. Crocker, F. Jones, and E. Yamamoto, then employed by the University of Hawaii. T. B. Jordan of the University of Hawaii made helpful modifications and suggestions on operation of the rainfall simulator.

CONTENTS

ERODIBILITY OF SELECTED HAWAII SOILS BY RAINFALL SIMULATION[1]

By E. W. Dangler, S. A. El-Swaify, L. R. Ahuja, and A. P. Barnett[2]

I. INTRODUCTION

Erosion hazards represent a serious threat to soil productivity and environmental quality. Nevertheless, there is an obvious lack of quantitative information necessary for predicting such hazards and for planning erosional control measures in the State of Hawaii. In addition, there is little knowledge concerning the erosive factors causing breakdown and transport of highly weathered tropical soils. Consequently, predictive capabilities for soil erosion losses, such as exist for mainland soils (*46*)[3], are not at present available in Hawaii. This has limited the Soil Conservation Service (SCS), the Environmental Protection Agency, the State Department of Health, and other concerned Federal and State agencies in their efforts to advise and educate land users or to formulate reliable soil erosion control criteria. These criteria must take into account hydrologic properties of soils as well as the interrelationships involving yield, transport, and deposit or recovery of sediments produced by erosion.

As a first step in a research project designed to investigate the above factors, a rainfall simulation study was begun in July 1972 on which preliminary results were published (*14*). The objective of the study was to determine the erosional characteristics of selected Hawaii soils under controlled rainfall applications. This report includes a detailed presentation, discussion, and analysis of the results.

II. LITERATURE REVIEW

Most of the available information on water erosion of soils has resulted from research outside the Tropics. Soil erodibility factors are tabulated for representative soils of the eastern two-thirds of the United States in USDA Agricultural Handbook 282 (*46*). However, there has been some ongoing research in

---

[1]This contribution by the University of Hawaii and the Agricultural Research Service (ARS), U.S. Department of Agriculture (USDA), was supported by Cooperative Agreement No. 12-14-5001-40, and published as Hawaii Agricultural Experiment Station Journal Series No. 1895 and Hawaii Institute of Geophysics, Contribution No. 674.

[2]Assistant soil scientist, professor of soil science, and assistant soil scientist, Department of Agronomy and Soil Science, University of Hawaii, Honolulu, and agricultural engineer, Southern Piedmont Conservation Research Center, ARS, Watkinsville, Ga., respectively.

[3]Italic numbers in parentheses refer to Literature Cited, p. 46.

soil erosion throughout tropical and subtropical areas, for example, in Africa.

Hudson (*23*) stated that soil loss by erosion is best measured by monitoring permanent plots, although in some instances, such as areas where cattle are concentrated, this method is unsuitable. He recommended measurements based on comparing soil surface level changes against fixed markers. His device consisted of a removable aluminum bridge that can be suspended between two permanent pegs. Roose (*33*) measured soil loss from forest plots (228 m^2, 9.5 percent slope) on ferrallitic soils in the Mid-Ivory Coast. Losses amounting to an average of only 6,000 kilograms per hectare per year (kg/ha/yr) were found with special selectivity for finer (0 to 20 μ) particles. Hurault (*25*), in a study of red ferrallitic soils in the Banyo area on the Adamson high plateau, reported that the extent of erosion was dependent on the infiltration capacity, which he found was in turn a function of termite presence. Thus, the presence of woody plants was deemed essential for erosion control in that region. Adu (*1*) described various forms of erosion in Ghana.

Elwell and Stocking (*16*) reported results of a 10-year research program in the Rhodesian highveld in which erosivity of natural rainfall was studied on fallow plots and on splash cups. In that area, rainfall occurs primarily during October to April (summer) as convective tropical thunderstorms of high intensity and short duration. He concluded that among raindrop velocity indices, a momentum parameter for rainfall impact was most closely related to soil losses from all plots. Earlier, Rose (*34*) had similarly found momentum to be significant in explaining soil loss from East African soils subjected to artificial rainfall as did Williams (*44*) in studies on subtropical soils in Australia.

These findings are in contrast to those of Wischmeier et al. (*47*), who found that soil losses were best correlated with the expression EI_{30} representing the product of the total kinetic energy of rainfall (E) and the maximum rainfall intensity for a given 30-minute period with the storm (I_{30}). Hudson (*24*) reiterated that only kinetic energies corresponding to rainfall intensities of more than 1 inch per hour (designated by him as $KE>1$) provide realistic estimates of rainfall erosivity in Africa. This is based on the fact that rainfall with lower intensities produces little or no soil erosion particularly in the highly weathered, well-structured soils of the Tropics and subtropics. In an earlier paper, Hudson (*22*) concluded that in a country such as Rhodesia, rainfall energy considerations--as determined by drop-size distribution, terminal velocity, and intensity--are not similar to their counterparts in temperate regions and that these differences need to be taken into account when rainfall simulators are designed for erosion studies in the Tropics.

Chibber et al. (*11*) conducted a laboratory-oriented erosion study in India and used the erosion ratio of Middleton (*32*) as the criterion for soil erodibility. Erodibilities of surface soils on shale were greater than those of the subsurface, whereas soils developed from sandstone or conglomerate were subject to greater erosion in the subsurface. Later, Haridisan and Chibber (*20*), in a study of several soils from the Malwa Plateau, reported highly significant positive correlations between the erosion ratio and both volume expansion and the moisture equivalent of the soil. Sharma and Datta Biswas (*36*) investigated the erodibility of four soil series occurring in a subtropical humid climate in northern India. Again, the erosion ratio served as the index of erodibility, but, as with the other studies, no actual data for soil losses were presented.

Lopez and Bonnet (*26*) tabulated maximum and minimum infiltration rates for seven soil orders found in Puerto Rico. Vertisols had the lowest values, whereas Oxisols and Ultisols, widespread in the humid Tropics, were among the highest. Manipura (*28*) compared mulched and bare plots on tea lands and found that in-

creased runoff and soil erosion were caused by the breakdown of the surface structure of soils during regular manual weeding. Bell (*8*) stated that erosion has been of concern for years on teak plantations in Trinidad and reported selected runoff data.

Barnett et al. (*6*) used the same rainfall simulator as used in this study (*31*) to measure soil erodibility factors (*K*- factors in the universal soil loss equation as in section VI) for several Puerto Rico soils. Of the three soil series tested, Humatas clay (an Ultisol) had a very low *K* factor of 0.004. Juncos clay and Pandura loam, both Inceptisols, had *K* factors of 0.017 and 0.113, respectively. A simulated hurricane rain of 12 in/hr intensity was applied to Juncos clay for 20 minutes after 5 inches of rain had already been applied. Soil loss per EI_{30} for the hurricane storm was three times greater than for the standard test at 2.5 in/hr intensity.

In Hawaii, awareness of erosion problems has existed for years. Sundquist (*40*) estimated that mechanical harvesting practices on sugarcane in the Ka'u District of the island of Hawaii resulted in soil losses of 2-1/2 in/acre per crop cycle before conservation measures were used. Runoff from equipment-compacted bare soils was 3 to 30 times greater than from hand-harvested, trash-blanket-protected lands. Christ (*13*) wrote a semipopular review article that discussed soil and water conservation practices in the islands. Accelerated erosion was traced to the advent of herds of animals including introduction of goats by British sea captains. Mechanization of sugarcane and pineapple harvesting was also noted as a key factor in soil and water losses. In fact, less than 1 percent of the land in Hawaii was rated class I (excellent) at that time.

Wood (*48*) compared infiltration rates for four soils on ungrazed forests with those for the same soils on adjacent pasture or cultivated land. With one exception, infiltration rates were highest and bulk densities lowest on forest lands. Forest and pasture soils had the highest proportion of water stable aggregates which, he suggested, indicate low erodibilities.

Erodibility indices were devised for wildland soils on Oahu and Hawaii by Yamamoto and Anderson (*49*) based on suspension percentage (*32*) and distribution of water stable aggregates. These indices were related to seven factors of which parent material followed by vegetative type were statistically most important in determining differences in water stable aggregates. The soils were slightly to moderately erodible under full vegetative cover. Among their more interesting conclusions was the statement that volcanic ash soils, because of their loose condition as well as their dispersive and slaking characteristics, may be twice as erodible as soils of basaltic flow or of colluvial origin.

More recently, Yamamoto and Anderson (*50*) used simulated rainfall (5.5 in/hr intensity, 4 mm drop diameter) from wool yarn to test their erodibility indices previously developed. Soil losses from water-saturated natural cores of Hydrol Humic Latosols, Humic Latosols, and Humic Ferruginous Latosols (mostly now classified as Inceptisols, Ultisols, and Oxisols, respectively) were obtained both as gross splash erosion and maximum splash rate. Yamamoto and Anderson were unable to arrive at a universal conclusion regarding susceptibility of different great soil groups (Orders under the new classification system) to splash erosion. Humic Ferruginous Latosols (Oxisols), however, had a wide range of splash loss. Sherman (*37*) had reported that these soils appeared to produce unstable granular structures during drought. Generally, Humic Latosols (Ultisols) had a low range of splash losses. Volcanic ash soil (Inceptisols) and Humic Ferruginous Latosols (Oxisols) had the highest splash loss rate, suggesting they would be more susceptible to loss from short duration, high intensity rains. According to Yamamoto and Anderson (*50*), ash and basalt collu-

vium soils may undergo greater erosion than basalt soils because their gross splash losses were highest.

Van't Woudt and Uehara (*43*) carried out quantitative studies of soil losses from 8- by 80-foot plots installed on stripmined "Aluminous Humic Ferruginous Latosols." Soil losses from bare, stripmined plots over a 20-month period were measured at 15.5 tons/acre. Erosion was very small on surface-protected soil but increased 20 times on unprotected, compacted soil. Lack of short-term, quantitative measurements prevented analysis of correlation between rainfall and erosion as done by Wischmeier et al. (*47*).

The SCS has published several pamphlets pertaining to erosion control in Hawaii. For example, Blewitt (*9*) discussed erosion control practices in general and specifically concentrated on diversion ditches on sugarcane plantations. The SCS (*39*) established minimum design criteria for builders. Bailey (*5*) gave preliminary guidelines for use of the soil loss equation in Hawaii and listed approximate estimates of soil erodibility factors for the various soil series.

It may be concluded that little information is available in the literature on the susceptibilities of tropical soils in general, and of Hawaii soils in particular, to erosion by water. Longer term studies are now in progress to provide some needed information under natural rainfall. However, this report contains results of a study in which rainfall simulation was used to provide quantitative information on the erodibilities of representative Hawaii soils more expediently than that which would be required for long-term studies.

III. METHODOLOGY

A. The Rainulator

The rainulator unit employed for the study was from the Southern Piedmont Conservation Research Center, ARS, USDA, Watkinsville, Ga. It consists of a portable frame on which carriages bearing spray nozzles are driven back and forth during operation across an experimental plot (*30*). Using appropriate controls, nozzles are allowed to apply a spray at an intensity of 1-1/4, 2-1/2, or 5 in/hr. The medium intensity was used throughout this study. As discussed elsewhere (*31*), the spray produced by the rain simulator approximates natural rain in drop-size distribution and kinetic energy at impact. Barnett and Dooley (*7*) compared the effects of natural and simulated storms on identical plots in Georgia and concluded that no real differences existed between the resulting sets of data if used for predicting soil losses from individual storms. Young and Burwell (*51*) obtained similar results from test plots in the Midwest. A minor drawback is that each bank of nozzles operates intermittently so that calculated energy of impact for a given quantity of applied rainfall represents average rather than actual energy. Moreover, the natural rainfall being simulated by this unit may not be as realistic for tropical rainstorms, such as prevail in Hawaii, as for regions in which it was designed. For example, in a 2-1/2 in/hr "rain" a bank of nozzles sprays only 20 percent of the time during the reciprocating carriage movement operative in the 10- to 11-second cycle.

Some operating statistics include a waterline pressure of 40 pounds per square inch reduced to 6 lb/in^2 at each nozzle, producing a 4-gal/min application through each nozzle. Long and short plots contained 48 and 24 nozzles per 900 ft^2 or 420 ft^2, respectively. Nozzle heights were 8 ft above the plot surface. The average kinetic energy of impact is 800 ft-tons/acre/in in storms of 2-1/2 in/hr (*31*).

B. Steps in Site Preparation

1. Laying Out and Clearing the Site

The first step in laying out the sites was to determine the slope steepness with a Dumpy level and a rod and then to establish stakes at four corners of the site. Refined level measurements were made later. Existing vegetation was removed by pick, shovel, or hand. However, at many of the sites, plowing had been done shortly before the tests, making weeding unnecessary. When two 420-ft^2 plots were to be run simultaneously, a 36-ft baseline was established across slope by two stakes. Two 35-ft lengths were measured at right angles from the ends of this baseline, and the top of the rectangle was completed by adjusting the top stakes to satisfy diagonals of 50 ft 2-1/2 inches. Then stakes were located at the top and bottom centers of the site, that is, 18 ft from the corners (fig. 1). Although other sites required different overall dimensions, the basic steps remained the same.

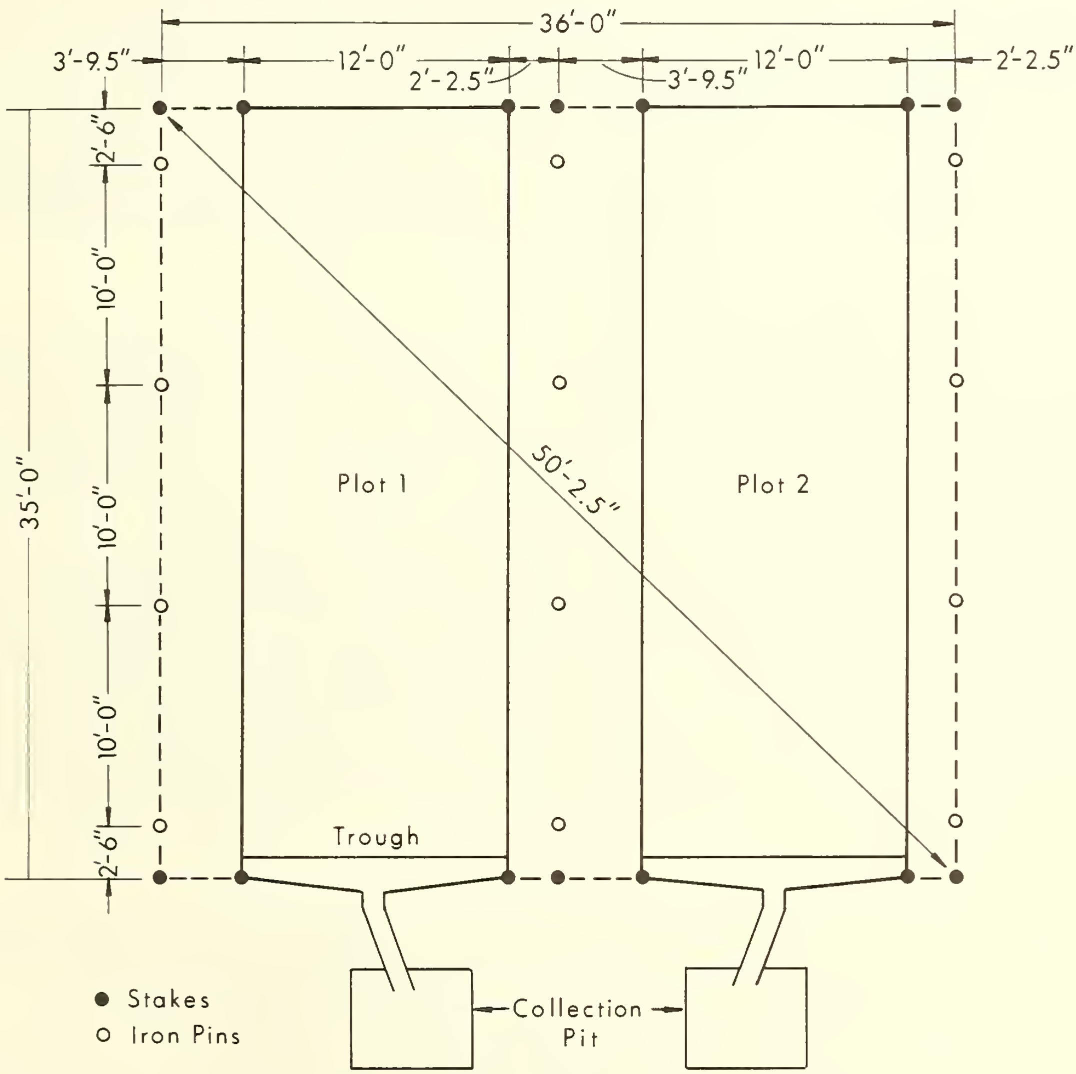


Figure 1.--Schematic of site layout, two 35-foot-long plots.

2. Plot Shaping

In all sites on the Kunia substation, Hawaiian Sugar Planters' Association, Oahu (sites 1-9), a bulldozer was used for reshaping. Sites 1-6 had furrow ridges knocked over into the furrows to provide plane surfaces for the slopes. Site 7 was drastically bulldozed for a reshaping that required 6- to 9-inch excavations of soil at the lower portion with refilling in the upper third of the site to approach a standard 9-percent slope. Site 8 was even more drastically altered as a 12-inch excavation was made. Site 9 was superimposed on site 8 but with a run and 4 days interposed.

3. Erecting the Rainulator

Starting 2-1/2 ft from the bottom stakes, iron pins, about 1 ft long, were driven into the soil at 10-ft intervals on the sides and centerline of the site (fig. 1). The support feet for the frame were placed on the pins. Starting at the last support feet upslope, the four-man crew erected an aluminum frame section and secured it with two guy wires to anchors upslope. In similar fashion, the remaining frames were erected, interconnected by aluminum spacers, and secured with lateral guy wires or end guy wires as necessary. After careful frame alinement, carriages were rolled onto the frame tracks, and drive rods and chains were installed. It was then a matter of arranging irrigation pipes, banks of solenoids, and bleed lines and connecting appropriate hoses to the carriages. Hookup of the drive engine to the drive rod installed on the frame made the rainulator mechanically operative, assuming alinement was correct.

4. Rototilling and Installing Plot Boundaries

After heavy traffic on the site during rainulator erection, a rototiller (Merry tiller, 5-hp engine) turned the soil over to a depth of about 6 inches. The decision to follow this procedure was made after eight sites had been studied. It was thought that this would allow more uniform surface preparation among soils. At any rate, the process reduced soil compaction and allowed easier grading.

Plot corner stakes were installed such that widths were 12 ft with lengths 35 ft (short) or 75 ft (long) for 420-ft^2 or 900-ft^2 plots, respectively. Next, 9-inch-wide corrugated steel siding was driven 6 inches into the soil on plot sides to prevent lateral water movement. Siding was not installed on the top border until harrowing had been completed immediately before the test run. At the lower end of the plot, a trough was positioned to collect runoff. Troughs were furnished with 5-inch flashing to reduce subsurface flow out of the plot. A pipe was connected to the trough's outlet, leading to a sample collection pit. All connections were sealed with electrical tape to eliminate runoff loss.

5. Grading Plot

To obtain a uniform slope, depressions were filled by raking and, when necessary, adding soil from outside the plot. A string, extending from the surface of plot corner stakes to the trough ends, guided the grading. Except for sites 1-9 on Oahu, all sites were prepared without bulldozing although plowing had been done on nearly half the sites. After soil sampling and hole filling, the final plot was prepared with a spike-toothed drag-harrow pulled upward parallel with the slope to minimize rill meander during runoff.

C. Water Sources

Fresh water was used during the study and, where possible, was drawn from irrigation ditches with a gasoline driven centrifugal pump equipped with a screen-fitted suction hose, foot valve, and 3-inch-diameter irrigation pipe and fittings for carrying water to the rainulator. Where irrigation ditches were not available, direct connection to county waterline hydrants proved satisfactory except for occasional waterline pressure variations. Even with ditchwater, there were occasional problems, such as the pump becoming clogged with snails or the control valves being fouled with algae.

D. Collection of Field Data

1. Before Runs

a. *Soil surface samples.*--Approximately 5 to 10 lb of soil were scooped up by hand from the surfaces of short and long plots, respectively. These samples were for future use in related laboratory analyses.

b. *Soil moisture samples.*--Soil moisture samples were collected within 30 minutes before each run with a 4-inch auger. Depths of 0 to 3, 3 to 6, 6 to 12, 12 to 18, and 18 to 24 inches were sampled. Two sets of these were taken from short plots and four from long. Occasionally, rocks interfered with the sampling or one or more layers.

c. *Plot profile.*--Prior to dry runs, plot profiles were made on each plot with a Dumpy level and rod. Rod readings were taken every 10 ft on each side of the plots. Thus, 8 values were obtained for short plots and 16 for long plots from which plot slopes were deduced.

2. During Runs

The experimental plan was to simulate two severe storms on successive days, an occurrence not unusual in the Tropics. Therefore, initial rainulator tests, hereafter referred to as "dry runs," were conducted on soils at the antecedent moisture that prevailed at the time. Within 16 to 24 hr, the majority of sites received similar tests, hereafter called "wet runs." Each run was planned for 120 min at rainfall intensities of 2-1/2 in/hr. When mechanical problems interrupted operation, an attempt was made to achieve a total of 120 min of application. The desired 2-1/2 in/hr rain was achieved by timing each bank of three nozzles per plot to spray once for every two carriage cycles.

a. *Runoff samples.*--Runoff samples were collected in quart-sized milk bottles at predetermined times after runoff began. Thus, a sample was obtained at 1-min intervals for 10 min after runoff commenced. Two samples were subsequently collected at 3-min intervals. In general, the collection intervals increased to 5 min after 25 min and to 10 min after 50 min of the test. Samples were obtained by passing the bottle mouth back and forth across the pipe outlet rather than holding the bottle stationary under it. This avoided concentrating the heavier sediments in the sample, thereby introducing errors in the sediment concentration of collected samples.

b. Measurements of runoff rate.--These were conducted between sample collections. Flow rates were deduced from the times (determined by a stopwatch) necessary to fill 1- or 2-gal containers. Early in runoff, however, rates were determined directly as the quart-sized sample bottles were being filled.

c. Rainfall measurements.--Rain gages, constructed as calibrated aluminum channels and covered by screen, were positioned across the plot at an angle to the plot boundary. At the downslope end of each gage, a rubber hose fitting was provided to drain collected water into a covered 3-gal bucket. Buckets were emptied into 2-gal rate-measuring containers after 60 min of rainfall application and at the end of each run as their capacities were insufficient for the duration of each run.

3. After Run

a. Terminal runoff sampling.--One minute after rain ended, a runoff sample was collected. Occasionally, a simultaneous measurement of runoff rate was made. Finally, the time at which runoff terminated was recorded.

b. Soil moisture samples.--Soil moisture samples were collected, within 30 min after runoff ceased, at the identical depth increments that the antecedent samples were collected.

c. Recording total rainfall.--The rainfall measuring buckets were emptied and the contents volumetrically measured and recorded.

d. Bulk density samples.--Bulk density samples were collected 2 to 10 days following the run. Generally, two samples were taken from small plots and four from large. The sledge hammer-driven core sampler had an inner cylinder 7.50 cm long and a 7.4-cm diameter, which is a volume of 322.4 cm^3. Samples were stored in paper or plastic bags and returned to the laboratory. Later in the study, a larger, two-man San Dimas core sampler was used on a number of sites for which the original data were missing or unreliable. The volume of the core cylinder in this sampler is 580.5 cm^3.

e. Organic residue samples.--These residue samples were obtained from each plot using a metal frame, 1 ft^2, which was tossed randomly onto the plot. With this frame denoting a square-foot surface, a cubic foot of soil was excavated in 3-inch increments using a large knife and hand trowel. These soil increments were placed in labeled plastic bags and returned to the laboratory.

E. Laboratory Analyses

1. Total Sediment

Sediment in each collected container was induced to flocculate by addition of 2 to 10 drops *N* HCl per quart. After settling overnight, the supernatant was discarded and the sediment transferred to a preweighed beaker and dried for approximately 36 hours at 100° to 110° Celsius. Sediment weight was then determined and plotted as soil loss versus time within the run.

2. Soil Moisture Determinations

Soil moisture was determined, using the standard procedure of heating soil in the moisture cans, for about 36 hr in an oven (Thelco, Precision Scientific Co.) at 100° to 110° C.

3. Bulk Density Measurements

Samples collected with cores of known volume were ovendried for 48 hr at 100° to 110° C. Bulk densities were calculated by dividing the determined weights by 322.4 cm^3 or 580.5 cm^3, both of which represent the volumes for the two core samplers used.

4. Organic Residue Determinations

Samples obtained from Oahu erosion sites were spread out in a greenhouse and air dried. Larger pieces of stems and roots were separated by hand. Smaller organic material was skimmed off after flotation by mixing with water in a plastic container. The separate residue was air dried and weighed.

Organic residue samples from soils of the island of Hawaii were separated in the field. Samples were emptied into buckets of water and mixed thoroughly. Floating plant debris was skimmed off the surface by hand and, finally, with a fine mesh screen. This material was dried in the laboratory and weighed as before.

F. Calculation of Sediment Losses, Runoff, and Infiltration Rates

Sediment loss and runoff were calculated for the various time intervals from the measurements of runoff rates and sediment content of the runoff water at specific times. Linear interpolations were used, where necessary, to calculate simultaneous values for both the runoff rate and sediment contents. Infiltration rates at any given time were determined by the difference between the average intensity of applied rainfall (assumed to be constant for the entire duration of the storm) and the runoff rate at that time. Most of the calculations were made by computer, employing a program that is given and explained in the Appendix. For the purpose of these calculations, interruptions due to occasional machine breakdown within a run were ignored. Rather, the assumption was made that the test run was continuous, and the interruption time interval, reported in relevant following sections, was omitted. As expected, this procedure caused a discontinuity in the measured runoff rate whenever that time interval was appreciable.

IV. THE SOILS

Selected soils belonging to five of the important orders in the State were studied. Inceptisols, Oxisols, Ultisols, and Vertisols were tested on the island of Oahu and Aridisols and Inceptisols on Hawaii.

A. Island of Oahu

1. Molokai Series

Molokai soils occupy more than 36,000 acres on the islands of Maui, Lanai, Molokai, and Oahu. According to Foote et al. (*17*), the soils are well drained and are found on nearly level to relatively steep slopes from near sea level to 1,000 ft on all islands and up to 1,500 ft on Lanai. Parent material is basic igneous rock. Mean annual soil temperature is 73° F and annual rainfall amounts to 20 to 25 inches, most of which occurs from November to April; summers are hot and dry. Major uses are sugarcane, pineapple, pasturage, and wildlife habitats, as well as homesites. Two different locations were selected for this soil.

a. Molokai-A soils.--The soils tested on sites 1-9 (Hawaiian Sugar Planters' Association, Kunia Substation) are Molokai silty clay loam classified as members of the clayey, kaolinitic, isohyperthermic family of Typic Torrox (Oxisols). Sites 1 and 3 represent a severely eroded phase of the soil. All sites were in continuous sugarcane cultivation for several years prior to the tests.

b. Molokai-B soils.--Sites 12, 14, and 15 were selected for Molokai-B soils in field 410, Oahu Sugar Company, Waikele. These sites, also silty clay loams, occur at slightly higher elevation than the Molokai-A sites, receive more natural erosion, and were not in use for several months prior to the initiation of the studies.

2. Wahiawa Series

Wahiawa soils occupy nearly 21,000 acres on Oahu. The soils are well drained and are found on nearly level to moderately steep slopes at elevations of 500 to 1,200 ft (*17*). Parent material is old alluvium and basic igneous rock. Mean annual soil temperature is 71° F and annual rainfall amounts to 40 to 60 inches annually, most of which occurs from November to April. These soils are very important pineapple soils but also support some sugarcane, pasturage, and homesites. The soils, represented by sites 16 and 17, are Wahiawa silty clays and are members of the clayey, kaolinitic, isohyperthermic family of Tropeptic Eutrustox (Oxisols). The sites were located in field 4101, Dole Company near Mililani town.

3. Waipahu Series

Waipahu soils occupy approximately 2,300 acres on the island of Oahu. The soils are relatively well drained and are found on nearly level to moderate slopes at elevations of sea level to 125 ft (*17*). Mean annual soil temperature is 75° F, and annual rainfall amounts to 25 to 35 inches, most of which occurs from November to April. Parent material is old alluvium derived from basic igneous rocks. Major uses are sugarcane and homesites. Sites 10, 11, and 13 are Waipahu silty clay, classified as members of the very fine, kaolinitic, isohyperthermic family of Vertic Ustropepts (Inceptisols). They were located in field 30, Oahu Sugar Company near Waipahu.

4. Lualualei Series

Lulualei soils occupy over 12,500 acres on coastal plains, alluvial fans, and talus slopes on the islands of Kauai, Oahu, Molokai, and Lanai. According to Foote et al. (*17*), the soils are well drained and are found on nearly level to gentle slopes at elevations of 10 to 125 ft. The parent material is alluvium and colluvium from basic igneous rock. The mean annual temperature is 75° F, and rainfall varies from 10 to 50 inches a year depending on the island, most of which occurs from November to April. Major uses are sugarcane, truck crops, pasturage, wildlife habitats, urban development, and military installations. Selected sites 20, 21, and 22 were located at the U.S Navy Radio Transmitting Facility, Lualualei. These soils are Lualualei clay, members of the very fine, montmorillonitic, isohyperthermic family of Typic Chromusterts (Vertisols).

5. Waikane Series

Waikane soils occupy nearly 12,000 acres of alluvial fans and terraces on the windward side of Oahu. According to Foote et al. (*17*), they are well-drained soils, which developed from alluvium and colluvium derived from basic igneous rock. The soils are found on nearly level to very steep slopes at elevations of 200 to 1,000 ft and mean annual soil temperature is 71° F. Rainfall is well distributed throughout the year,ranging from 50 to 70 inches. Major uses are pasturage, truck crops, and homesites. Site 23 was located at Kamiyama Farm, Kahaluu, at 155 feet elevation and sites 24 and 25 at Kamiya Farm, Waihole, at 40 feet elevation. All are Waikane silty clay, members of the clayey, kaolinitic, isohyperthermic family of Humoxic Tropohumults (Ultisols).

B. Island of Hawaii

Soils that were investigated on this island were derived from volcanic ash. Five series were studied:

1. Kukaiau Series

Kukaiau soils occupy about 10,000 acres on the Hamakua Coast of the island of Hawaii. These soils are well drained and are found on gentle to steep slopes at elevations of 500 to 1,500 ft (Sato et al., *35*). Mean annual soil temperature ranges from 67° to 69° F, and annual rainfall, from 70 to 100 inches. Major use is sugarcane although small areas are used for truck crops, macadamia nuts, and pasturage. Sites 26 to 33 are Kukaiau silty clay loam located in field 24-B, Hamakua Mill Company, Paauilo, Hawaii. The soil is a member of the thixotropic, isothermic family of Hydric Dystrandepts (Inceptisols).

2. Hilo Series

Hilo soils occupy more than 14,000 acres in Hawaii. They are well-drained soils formed from a series of volcanic ash layers that give them a banded appearance and are found on gentle to steep slopes at elevations near sea level to 800 ft (Sato et al., *35*). Mean annual soil temperature ranges from 72° to 74° F, and annual rainfall,from 120 to 180 inches. Major uses are sugarcane, truck

crops, orchards, and pasturage. Sites 34 and 35 were described as Hilo silty clay loam and were located at the Hilo Coast Processing Company, Pepeekeo, Hawaii. The soil is classified as a member of the thixotropic, isohyperthermic family of Typic Hydrandepts (Inceptisols).

3. Kawaihae Series

Kawaihae soils occupy nearly 29,000 acres of the island of Hawaii. The soils are excessively drained and stony, formed from volcanic ash, and are found on gentle to moderate slopes at elevations near sea level to 1,500 ft (*35*). Mean annual soil temperature ranges from 74° to 77° F, and annual rainfall, from 5 to 20 inches, most of which falls during winter months. Major uses include pasturage, recreation, wildlife habitat, and homesites. Sites 36, 37, and 38 are Kawaihae very rocky very fine sandy loam and were located at Kawaihae, Hawaii. The soil is a member of the medial, isohyperthermic family of Ustollic Camborthids (Aridisols).

4. Naalehu Series

Naalehu soils occupy approximately 5,000 acres on the island of Hawaii. They are well-drained soils, formed from volcanic ash, and found on nearly level to steep slopes at elevations from 750 to 1,800 ft (*35*). Mean annual soil temperature ranges from 72° to 75° F, and annual rainfall ranges from 35 to 60 inches. The soil is used mostly for sugarcane and some pasturage. Sites 39 and 40 are Naalehu extremely stony silty clay loam thin solum variant and are located on Ka'u Sugar Company land, Naalehu, Hawaii. This soil is a member of the medial, isohyperthermic family of Typic Eutrandepts (Inceptisols).

5. Pakini Series

Pakini soils occupy approximately 6,600 acres of the island of Hawaii. According to Sato et al. (*35*), the soils are well drained, were formed from volcanic ash, and occur on nearly level to gently sloping terrain from near sea level to 1,000 ft elevation. Mean annual soil temperature is from 72° to 75° F, and annual rainfall ranges from 20 to 40 inches. Major use is pasturage. Sites 41 and 42 are Pakini very fine sandy loam and are located south of United States Air Force Tracking Station, South Point, Hawaii. This soil is a member of the medial, isohyperthermic family of Entic Eutrandepts (Inceptisols).

Figures 2 and 3 show the geographic distribution of soil orders represented by this study on the islands of Oahu and Hawaii. Locations of experimental sites are identified on each.

V. Results

Data obtained from the rainfall simulation experiments are presented in this section in the same sequence as used previously to describe the soils (section IV). Note that some inconsistencies in the number of significant figures found in certain tables have been allowed for convenience in handling the large number of computerized data.

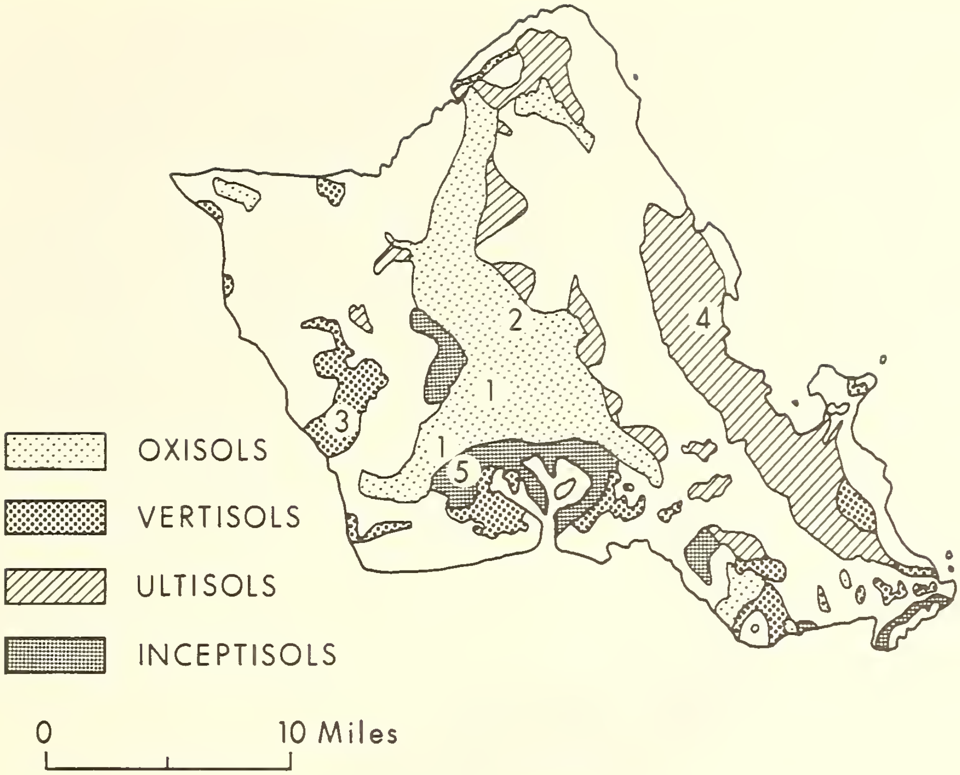


Figure 2.--Map of island of Oahu with generalized locations of soils tested (modified after Foote et al., *17*): 1, Molokai soil series; 2, Wahiawa soil series; 3, Lualualei soil series; 4, Waikane soil series; 5, Waipahu soil series.

A. Island of Oahu

1. Molokai Soil Series

a. Runoff.--Table 1[4] indicates that for dry runs on Molokai-A series, final cumulative runoff values ranged from 0.73 inch (35-ft plot length, 14.5 percent slope) to 2.60 inches on a similar length of plot of 10.7 percent. The average for the 17 plots tested was 1.83 inches, with little dependence on plot length (average for 9 long plots was 1.89 inches). Average experimental rainfall applied to the plots was 4.93 inches. This indicates that nearly 63 percent of the water applied infiltrated into the soil on an average plot. On the other hand, final runoff values for wet runs on this soil indicate a narrower range than above. Thus, a runoff range from 3.25 inches (35-ft plot, 5.1 percent slope) to 4.09 inches (35-ft plot, 14.9 percent slope) was measured, with an average of 3.72 inches for the six plots studied. Again, no dependence on plot length was noted (average for three long plots was 3.70 inches). The average rainfall applied during wet runs was 4.80 inches; thus, an average infiltration value of 1.08 inches was calculated for these plots. In contrast with dry runs, only 22.5 percent of the applied water infiltrated into the soil.

[4]For convenience, all tables appear in the Appendix at the end of this report.

The dependence of infiltration on initial soil water content is expected and is discussed quantitatively in section VII. Similarly, the time after which runoff started (table 11) also is expected to depend on the initial soil water content and is discussed quantitatively in section VII. A clear relationship is observed between total runoff and the time necessary for it to start. For dry runs, the average time until runoff started was 22.9 min; for wet runs, 2.5 min. In addition to higher initial water content, the larger amount and faster occurrence of runoff during wet runs may also be caused by the altered condition of the soil surface after application of the first storm. The plot surface acquired what appeared to be a surface seal, which probably contributed to the rapid runoff observed. The difference between dry and wet runs is clearly reflected by the 30-min runoff value (table 1). For dry runs, this ranged from 0 to 0.08 inch; for wet runs, 0.61 to 0.88 inch. Generally, intermediate values of dry runs indicate a slow buildup in runoff intensity during the 30- to 60-min interval followed by more steady runoff. Conversely, during wet runs, steady runoff values are achieved early in the tests.

Figure 3.--Map of island of Hawaii with generalized locations of soils tested (modified after Sato et al., *35*): 1, Kawaihae soil series; 2, Kukaiau soil series; 3, Hilo soil series; 4, Naalehu soil series; 5, Pakini soil series.

For sites on Molokai-B soils (table 1), final cumulative runoff values for dry runs ranged from 0.53 inch (75-ft length) to 3.36 inches (35-ft length) each with 4.6 percent slope. The average for the four plots tested was 2.25 inches, indicating an average infiltration of 49 percent of the average rainfall applied. Final runoff values for wet runs ranged from 4.15 to 4.21 inches with a two-plot average of 4.18 inches (omitting the wet runs on site 12 from consideration due to short duration). Thus, infiltration was reduced to 18 percent of the total average rain. Comparison shows that the average infiltration percentage is lower for Molokai-B soils than for Molokai-A soils. However, the average time required for runoff to start is the same for both soils during each test made (23 min, dry runs; 3 min, wet runs). Obviously, initial soil water conditions may provide additional explanation for different infiltration or runoff volumes as will be discussed below and in section VII.

b. Soil moisture conditions.--Antecedent soil moisture values for dry runs on both Molokai soils generally increased with depth from the surface. The pattern was reversed after the runs so that soil moisture decreased with depth (table 2). For Molokai-A, the topmost (0 to 3 inches) increment for dry runs had a range from 8 to 24.3 percent (omitting site 9 from consideration as it was superimposed on site 8, which had been tested only 4 days earlier). The average value was 15.8 percent. This is lower than the water retention at 15 bar, which was found to be 20 percent. As expected, this surface layer had an average soil-water content of 53.0 percent after rain application, which is close to the saturation water content for the soil. Antecedent wet run values for this same 0- to 3-inch increment ranged from 44.9 to 49.2 percent, with an average of 46.7 percent, indicating a significant drainage of soil water during the interim 16-hr period. The deepest increment (18 to 24 inches) had an average value of 34.5 percent prior to the dry runs, with a range of 28.7 to 43.5 percent. Values after the tests underwent only a small increase and ranged from 29.7 to 50.4 percent, with an average value of 38.2 percent. Antecedent wet run values averaged 38.7 percent, with a range of 31.4 to 46.1 percent for the six plots tested. Final values after the wet run ranged from 32.3 to 50.6 percent, with an average of 40.5 percent.

As shown in table 2, trends similar to those described above were noted for Molokai-B sites. However, these generally had higher antecedent water contents than did those for Molokai-A. For the 0- to 3-inch increment, values prior to dry runs ranged from 25.6 to 39.5 percent, with an average of 35.1 percent for the four plots tested. Average soil water for this increment after tests was 59.3 percent, with a range of 53.1 to 63.7 percent, decreasing to a range of 51.2 to 61.5 percent before the wet runs. Final values after wet runs averaged 58.5 percent, with a range of 57.6 to 59.1 percent. The 18- to 24-inch increment had an average antecedent soil water content of 33.1 percent, increasing to 38.5 percent after rain. Antecedent and final average values for wet runs in this deep increment were 46.2 and 46.9 percent, respectively.

c. Soil losses.--Table 1 shows cumulative soil losses from the Molokai-A test plots at various time intervals within each applied storm. Final cumulative losses ranged from 0.68 tons/acre (35-ft length, 14.5 percent slope) to 57.29 tons/acre (35-ft length, 10.2 percent slope), with an average value of 14.96 tons/acre for the 17 plots. Wet runs produced final cumulative soil losses ranging from 4.02 tons/acre (35-ft length, 5.1 percent slope) to 39.15 tons/acre (75-ft long, 15.4 percent slope). Losses after 30 min of rain ranged from 0 to 0.5 tons/acre for dry runs and from 0.73 to 10.91 tons/acre for wet runs.

Final total losses for Molokai-B soils ranged from 1.38 to 32.90 tons/acre for four dry run tests, with an average of 11.48 tons/acre. On the other hand, wet runs produced a greater final average soil loss, namely, 25.43 tons/acre, with a range from 25.25 to 25.60 tons/acre for two plots.

d. Organic residue.--As indicated in table 3, organic residue from Molokai-A soils on sites 1-8 was generally greater in the upper half of the cubic-foot samples collected. In more detail, the 0- to 3-inch increments sampled and weighed for each plot had a residue range from 0.0134 to 0.176 lb and an average value of 0.0729 lb for the 16 plots. The average contents in the 3- to 6-, 6- to 9-, and 9- to 12-inch increments were 0.0510, 0.0404, and 0.0271 lb, respectively.

The total organic residue values per cubic foot ranged from 0.0534 to 0.363 lb, with an average value of 0.191 lb for all 16 plots. This corresponds to a range of 1.16 to 7.89 tons/acre-ft, the average value being 4.15 tons/acre-ft.

Table 3 shows a similar trend for Molokai-B sites, namely, a general decrease of organic residue with depth. However, because the soil did not support recent sugarcane cultivation, the average values for a whole cubic foot were smaller than for Molokai-A. Expressed as tons/acre-ft, these values ranged from 0.88 to 1.56, with an average of 1.22 tons/acre-ft.

2. Waipahu Soil Series

a. Runoff.--Table 1, for sites 10, 11, and 13, shows a range of final cumulative runoff values for dry runs of from 0 (two 35-ft plots with 3.83 and 4.33 percent slopes) to 0.42 inch (75-ft plot with 5.56 percent slope). Runoff from these three plots averaged 0.14 inch; thus, an average of over 98 percent of the applied rainfall infiltrated into the soil. For wet runs, on the other hand, a range from 0.37 inch (35-ft plot, 3.83 percent slope) to 2.42 inches (75-ft plot, 5.56 percent slope) was measured for runoff with a mean value of 1.13 inches. Therefore, an average of 76 percent of the applied water infiltrated into the soil in this case. By comparison, a much greater fraction of water infiltrated into Waipahu soil than into Molokai soils. As noted in table 11, the time after which runoff started was 60 min in the only dry run that produced runoff. For wet runs, the average time was 14.3 min. Large clods, which were present at the start of dry runs, had slaked and nearly disappeared by the end of the run. Prior to the wet run, the soil surface had a smooth, skinlike appearance.

b. Soil moisture conditions.--According to table 2, soil moisture increased with depth prior to dry runs. The pattern after dry runs generally indicates fairly uniform wetting throughout the sampled 0- to 24-inch depth. The data further show that gravimetric water contents of Waipahu soil ranged from 11.3 to 22.9 percent prior to dry runs in the 3-inch increments examined, with an average of 18.5 percent. After the applied rain, this increment had a range from 39.0 to 46.1 percent moisture, with a mean value of 42.4 percent. These values decreased but slightly before the initiation of wet runs and were somewhat higher after these runs, with a range from 41.9 to 45.0 percent and a mean value of 43.6 percent.

c. Soil losses.--Final cumulative losses during dry runs ranged from 0 to to 1.284 tons/acre, with a mean value of 0.428 tons/acre for the three plots

tested (table 1). Plots run wet had final soil loss values ranging from 0.420 to 15.41 tons/acre for three plots, with an average value of 5.625 tons/acre. The delayed start of runoff is reflected by the soil loss after 30 min of the dry run, at which time there was no sediment loss on the average for the plots. During wet runs, the average loss after the 30-min interval was 0.509 tons/acre.

d. Organic residue.--As seen in table 3, no general pattern seems evident from the two plots examined. Distribution with depth similar to that observed for Molokai soils is noted here. Both plots had approximately the same total amount of residue.

3. Wahiawa Soil Series

a. Runoff.--The cumulative runoff values under dry runs ranged from 0.89 inch (75-ft plot, 7.09 percent slope) to 1.67 inches (35-ft plot, 5.73 percent slope), with an average of 1.21 inches for all plots (table 1). Subsequently, it may be calculated that of the total applied rainfall during dry runs, 72.7 percent infiltrated into the soil, a value that exceeds values obtained for either Molokai soil. For wet runs, total runoff values averaged 0.91 inch for the two plots tested. However, the experimental storm was not completed so that only 2.62 inches of rain fell on plot 1 and 2.57 inches, on plot 2. In view of these limited data, 65 percent of the water apparently infiltrated into the soil. As noted in table 11, runoff during dry runs started after 36 min of rain for two plots and 48 min for two others, with an average time of 42 min. The comparable average value for wet runs is 10 min.

b. Soil moisture conditions.—Soil moisture values listed in table 2, show, as for previous cases, that the plow layer consistently had lower water contents than the deeper increments. Water contents after dry runs were relatively uniform between the surface and deepest increments. These values decreased slightly during the time between dry and wet runs but rebounded to higher values after wet runs.

c. Soil losses.--Table 1 shows that final dry run losses ranged from 1.640 tons/acre (35 ft, 5.73 percent slope) to 5.750 tons/acre (75 ft, 7.09 percent slope), with an average of 3.413 tons/acre. Wet runs produced total sediment losses of 4.288 tons/acre (35 ft, 6.44 percent slope) and 5.819 tons/acre (75 ft, 7.09 percent slope) but, as indicated earlier, over a shorter timespan.

d. Organic residue.--As indicated in table 3, organic residue from Wahiawa soils was greater in the upper half of the collected cubic-foot samples. This concentration of residue near the surface is more than for the sugarcane-cropped soils discussed above. However, the total average contents in 1 ft , averaging 0.099 lb/ft^3 (2.16 tons of organic residue per acre-foot), were well within the values encountered on sugarcane soils.

4. Lualualei Soil Series

a. Runoff.--As shown in table 1, dry runs had a range of final cumulative runoff from 2.07 inches (35-ft plot, 3.53 percent slope) to 2.60 inches (75-ft plot, 3.04 percent slope), with a mean value of 2.34 inches. Compared with

average applied rain, 5.01 inches, approximately 53 percent of the applied rainfall infiltrated into the soil. For wet runs, a runoff range from 3.75 to 4.02 inches was measured, with a mean value of 3.89 inches on the two plots tested. Thus, only 22 percent of the rain infiltrated into the soil on an average plot. This decrease in infiltration after the dry run was the largest noted for soils on Oahu not receiving recent normal tillage practices. As noted in table 11, runoff began after an average of 18 min for dry runs, with a range from 15 to 21 min. In contrast, for wet runs, the average time was 5.0 min. These are short times when the gentle slopes of these sites are considered.

b. Soil moisture conditions.--Table 2 shows the usual trend for soil moisture distribution within the profile before dry runs. After dry runs, this trend was reversed so that a decrease of soil water content was noted with depth. A significant change occurred in this distribution during the time lapsing between dry and wet runs, thus reflecting a faster drainage with this soil than expected. Little change in water content occurred in the soil profile as a result of rain application during the wet run.

c. Soil losses.--Table 1 shows that total losses after dry runs ranged from 2.170 tons/acre (75 ft, 3.37 percent slope) to 4.306 tons/acre (75 ft, 3.04 percent slope), with a mean value, 3.062 tons/acre, for the three plots studied. Losses after wet runs were 2.675 tons/acre (75 ft, 3.37 percent slope) and 4.466 tons/acre (75 ft, 3.53 percent slope).

d. Organic residue determinations.--Table 3 shows that residue clearly decreased with depth in the cubic-foot, soil-residue samples collected, more so than in the case of Wahiawa soil. The mean value of organic residue obtained from total cubic-foot samples was 0.298 lb. This was the greatest amount of residue per cubic foot obtained from any soil series tested on Oahu and corresponds to 6.49 tons/acre-ft.

5. Waikane Soil Series

a. Runoff.--For sites 23, 24, and 25, cumulative runoff for dry runs ranged from 0 (75-ft length, 4.8 percent slope) to 0.49 inch (35-ft length, 11.9 percent slope) as indicated in table 1. Average value for the three plots studied was 0.27 inch. Comparison with applied rainfall indicates that approximately 97 percent of the total infiltrated into the soil. For wet runs, a range from 0.13 inch (75-ft length, 4.80 percent slope) to 2.22 inches (75-ft length, 12.2 percent slope) was found with a mean value of 1.49 inches. Therefore, an average of approximately 75 percent of the water applied during wet runs infiltrated into the soil profile. This value corresponds closely to the 76 percent infiltration found for Waipahu soil series. Th5 time runoff commenced, as listed in table 11, ranged from 60 to 82 min with a mean value of 71 min for the dry runs. Site 23 experienced no runoff. Wet runs averaged 20.7 min for runoff to start with a wide range from 2 to 28 min recorded for the three plots tested.

b. Soil moisture conditions.--Table 2 shows confirmation of the usual antecedent condition of increasing soil water content with depth, as was noted for all other soils. Following dry runs, moisture values were fairly uniform throughout the 0- to 24-inch depth, except for site 23 in which 20 percent more water content was measured in the 12- to 24-inch increments than in the upper

increments. Antecedent wet run measurements showed the same pattern as final dry runs, although with reduced moisture values. Final wet run moisture values were rather uniform throughout the depths sampled for two sites but increased significantly in the 6- to 24-inch depths on site 23.

c. Soil losses.--Table 1 shows that final cumulative soil losses during dry runs ranged from 0 to 2.294 tons/acre with a mean value of 1.095 tons/acre for the three plots. Wet run losses ranged from 0.037 to 19.50 tons/acre, with an average of 9.529 tons/acre. Delayed runoff in dry runs resulted in nil value for sediment losses after 30 min. Wet run losses after 30 min ranged from 0 to 4.020 tons/acre, with a mean value of 1.433 tons/acre.

d. Organic residue.--The limited data available indicate almost twice as much organic residue in the upper 6 inches of the cubic foot samples compared with that of the lower 6-inch layer. Total residue averaged 0.060 lb/ft^3, a value that is closely comparable to the average values found for Waipahu and Molokai-B soils. Other Oahu soils studied had greater organic residues.

6. Plantation Roads

Rain simulation was conducted on two roads: one, a sugarcane field road on Molokai-B soil and the other, a pineapple field road on Wahiawa soil. Neither was subjected to the plot preparation procedure outlined in section III. Due to size limitations, only 35-ft-long, 6-ft-wide plots were studied.

a. Runoff.--Table 1 shows that total runoff during the dry run was 3.42 inches for the sugarcane road, which represented 66 percent of the total applied rain. The corresponding value for the pineapple road was 73 percent. During wet runs, the sugarcane road produced a runoff of 4.47 inches (80 percent of the applied rain) and the pineapple road, 3.82 inches (85 percent of the applied rain).

b. Soil moisture conditions.--Table 2 shows that antecedent water contents for the 0- to 3-inch increment were considerably higher for the two roads than for their soil counterparts. The values were 21.6 percent for the Molokai (sugarcane) road and 29.0 percent for the comparable Wahiawa (pineapple) road. These increased after the dry runs to 41.2 and 49.5 percent, respectively. During the interim period preceding wet runs, one value remained the same (41.5 percent) while the other decreased (43.5 percent). Both increased after the wet run to 46.4 and 45.9 percent, respectively. Water redistribution within the Wahiawa road occurred more readily than for the Molokai road as evidenced by deeper wetting in the former than in the latter after the dry runs.

c. Soil losses.--The final soil loss for the dry run of 91.5 min on the sugarcane raod (table 1) was 4.913 tons/acre. Loss resulting from 120 min of rain of the pineapple road was 8.051 tons/acre. Thirty-minute losses were 1.875 and 1.348 tons/acre for the sites, respectively. Final wet run losses were 7.540 tons/acre for the sugarcane road and 7.714 tons/acre for the pineapple road, with 30-min losses of 4.740 and 2.147 tons/acre, respectively.

d. Organic residue.--No organic residue was collected from the sites on plantation roads. However, both roads were devoid of visible surface vegetation.

B. Island of Hawaii

Tests were conducted on 17 sites involving five soil series derived from volcanic ash on the island of Hawaii.

1. Kukaiau Soil Series

a. Runoff.--Table 1 for dry runs indicates a range of final runoff values from 0.56 inch (35-ft length, 14.27 percent slope) to 3.51 inches (35-ft length, 5.80 percent slope) with a mean value of 1.50 inches. Because three of the eight test storms were less than 100 min long, a lower average rainfall than intended (4.42 inches) was applied. Thus, approximately 66 percent of applied rain infiltrated into the soil profile during dry runs. For wet runs, on the other hand, runoff ranged from 1.22 to 2.44 inches, with an average value of 1.85 inches. Thus, in this case, only 31 percent of the applied rain infiltrated into the profile. Table 11 shows that runoff started after an average of 21.1 min during dry runs, with a range from 10 to 39 min recorded. Wet runs generated runoff in 4 min on the average, with a 3- to 5-min range.

b. Soil moisture conditions.--Table 2 shows that soil moisture contents generally increased with depth prior to dry runs. No clear pattern was evident after dry runs, although the majority of plots had increased water contents with depth. On several plots, there was an unusually large increase in soil moisture in the 12- to 18-inch increment in comparison with the increment situated above this increment. Some decreases in these water contents were noted before wet runs and values continued to increase with depth. Apparently, the same trend was generally true for the final wet run values, although several anomalies were in the array of values for the four plots tested. The different nature of volcanic ash soils and higher natural rainfall were reflected in the soil's moisture contents, which ranged from 24.0 to 59.1 percent and averaged 43.1 percent in the 0- to 3-inch increment prior to dry runs. After experimental rain this same increment had moisture contents that ranged from 53.9 to 96.5 percent, with a mean value of 72.2 percent for the 16 plots tested. Antecedent wet run values in the 0- to 3-inch increment ranged from 52.4 to 77.6 percent, with an average of 66.1 percent. Following wet runs, the soil moisture values ranged from 69.3 to 93.2 percent, with a mean value of 78.5 percent.

c. Soil losses.--Table 1 shows that final cumulative losses during dry runs ranged from 0.887 to 24.96 tons/acre, with a mean value of 7.732 tons/acre for the 16 plots studied. Wet runs resulted in final average soil losses of 8.275 tons/acre, with a range of 4.162 to 14.33 tons/acre. Sediment losses after 30 min of applied rain ranged from 0 to 1.326 tons/acre for dry runs and 0.831 tons/acre to 5.573 tons/acre for wet runs on the four plots tested.

d. Organic residue.--As shown in table 3, organic residue from Kukaiau soil, in general, decreased with depth. Furthermore, the mean value for total residue collected from 16 samples was 0.201 lb/ft^3. This was a higher value than for any comparable soil receiving recent normal tillage practices on the island of Oahu.

2. Hilo Soil Series

a. Runoff.--Data for dry runs on sites 34 and 35, as listed in table 1, showed an extremely narrow range of runoff from 3.49 inches (35 ft, 8.80 percent slope) to 3.85 inches (35 ft, 8.40 percent slope); the average was 3.64 inches. Comparison with average applied rainfall showed that only 25 percent of the experimental rain infiltrated into the soil profile. Final cumulative wet run values averaged 3.95 inches so that approximately 21 percent of the applied rain infiltrated into the soil. Evidently, runoff, and thus infiltration, did not differ appreciably between dry and wet runs, a fact that is explained by the natural wet condition throughout the profile of this volcanic ash soil (see b. below). As noted in table 11, the time required to initiate runoff ranged from 8 to 19 min for dry runs, with a mean value of 13.8 min. Runoff in wet runs commenced after 7 min of rain for both plots studied. Again, this does not reflect the usual large difference between dry and wet runs noted for many drier soils.

b. Soil moisture conditions.--Table 2 shows that water contents prior to dry runs generally increased with depth. For example, the 18- to 24-inch increment averaged 275 percent moisture, whereas the 0- to 3-inch increment had a mean value of 148 percent. This trend still held true even after runs, despite the absence of certain data. Unexpectedly, considerable drying of the surface soil during the interim period between dry and wet runs is indicated from antecedent wet run soil moisture values. This indicates relatively fast drainage of applied water, much of which is probably held in macropores between soil structural units. The excessively high natural water contents of these soils explain the small differences in runoff observed between dry and wet runs.

c. Soil losses.--Table 1 shows that cumulative sediment losses from dry runs ranged from 4.141 tons/acre (35 ft, 8.30 percent slope) to 6.328 tons/acre (35 ft, 8.80 percent slope), with a mean value of 4.780 tons/acre. Wet run tests produced a range of soil losses from 4.203 tons/acre to 6.125 tons/acre, with a mean value of 5.164 tons/acre. Note that, in general, soil losses did not accelerate as rapidly during the runs as noted for tests on other soil series. Furthermore, sediment losses under the large runoff incurred were far below comparable sites on other soil series.

d. Organic residue.--Table 3 indicates that organic residue from Hilo soils was more abundant in the upper 6 inches of collected samples than in the lower 6 inches. The overall average for organic residue was 0.138 lb/ft^3, which is higher than most of the Oahu samples collected but is the lowest collected from any soil series on the island of Hawaii.

3. Kawaihae Soil Series

a. Runoff.--Cumulative runoff data for sites 36 and 38, as listed in table 1, show that values for dry runs ranged from 2.06 inches (35 ft, 8.73 percent slope) to 3.51 inches (35 ft, 11.03 percent slope), with an average value of 2.76 inches. Sites 37 had only a run of short duration and is not taken into account. Comparison of runoff with average applied rainfall shows that 44 percent of applied rain infiltrated into the soil. This value is lower than that observed on Kukaiau soil but considerably higher than that observed for the Hilo

soil. For wet runs, total runoff averaged 3.01 inches, with a range from 2.33 inches (35 ft, 9.36 percent slope) to 3.65 inches (35 ft, 11.03 percent slope). Thus, because applied rain averaged 4.17 inches, only 28 percent of the rain infiltrated into the soil profile during the tests. From table 11, runoff during dry runs started after 11.8 min of rain on the average, with a range of 9 to 16 min. Corresponding values for wet runs averaged 1.8 min, with a narrow range of 1 to 2 min recorded.

b. Soil moisture conditions.--Table 2 reveals that antecedent dry run soil moisture values (field conditions) of Kawaihae soil generally do not vary greatly from surface to 24 inches in depth. However, after the run, wetting of the profile is achieved to only about 12 inches because the soil moisture values in the 12- to 24-inch increments are lower than those increments above. Antecedent dry run water contents in the 0- to 3-inch increments were generally higher than expected for this Aridisol and ranged from 23.2 to 27.5 percent moisture, with an average of 26.0 percent. After the dry run, the range varied from 41.4 to 42.5 percent, with a mean value of 41.9 percent. Antecedent wet run values in the same increment averaged 32.3 percent and rose to a mean value of 39.3 percent after wet runs. For the 18- to 24-inch increment, antecedent dry run values averaged 25.3 percent and changed only slightly to an average 26.3 percent after the dry run. Drainage overnight allowed better wetting of this increment so that water contents before wet runs averaged 36.5 percent. Again, little change occurred during the wet run.

c. Soil losses.--Total dry run losses ranged from 10.65 tons/acre to 26.47 tons/acre (table 1), with a mean value of 15.67 tons/acre. Wet runs produced total final sediment losses ranging from 7.914 tons/acre to 18.22 tons/acre with an average of 13.50 tons/acre. Soil losses after 30 min of rain were extensive compared with other soils used in this study; during dry runs, the average loss was 1.478 tons/acre; during wet runs, 3.649 tons/acre.

d. Organic residue.--As shown in table 3, the usual pattern of greater amounts of organic residue in the upper portions of the collected samples is not as evident in Kawaihae soils as in other soils tested. This is surprising because the soil was not under cultivation, and, therefore, no redistribution of organic residue would be expected as is the case in croplands with regular plowing. Two of the four plots had more residue in the 6- to 12-inch zone than the upper 6 inches of soil. In one plot, organic residue was uniformly distributed through the 1-ft depth; the last plot had greater residue in the upper half of the cubic-foot sample. Total weights of residue ranged from 0.199 to 0.355 lb/ft^3 for four plots sampled. The mean value of 0.274 lb/ft^3 was exceeded only by that found from Pakini sites on the same island of Hawaii. This reflects the fact that the soil supports appreciable vegetation during winter months when natural rainfall is more abundant.

4. Naalehu Soil Series

a. Runoff.--Table 1 shows that dry runs for sites 39 and 40 had total runoff ranging from 2.38 inches (35 ft, 8.57 percent slope) to 2.89 inches (35 ft, 6.60 percent slope), with an average of 2.67 inches. Comparison with applied rain shows that 45 percent infiltrated into the soil profile during dry runs. For wet runs, total runoff ranged from 4.17 inches (35 ft, 6.60 percent slope) to 4.27 inches (35 ft, 8.57 percent slope), with a mean value of 4.22 inches.

Thus, only 7 percent of the applied rain infiltrated into the soil during wet runs. Table 11 shows that runoff started after an average of 18.5 min during dry runs, with a range from 10 to 29 min. In contrast, runoff commenced after an average of 1 min during wet runs.

b. Soil moisture conditions.--As noted from table 2, only a few soil samples were obtained from deeper layers because of the presence of rocks and the shallowness of the soil. As expected, soil moisture increased with depth prior to dry runs. For example, water contents in the 0- to 3-inch increments averaged 53.4 percent and in the 6- to 12-inch increments averaged 64.3 percent. For wet runs, average antecedent values for the two increments were 68.5 and 75.8 percent becoming 70.1 and 73.2 percent, respectively, after wet runs.

c. Soil losses.--Final losses from dry runs ranged from 3.711 to 17.45 tons/acre with a four-plot average of 10.53 tons/acre (table 30). The two plots that served for wet runs had sediment losses of 8.204 and 10.45 tons/acre. Thirty-minute results indicated dry run losses that averaged 0.215 ton/acre (0.002 to 0.406 ton/acre). Wet run losses were much higher, ranging from 1.628 to 2.461 tons/acre, with a mean value of 2.045 tons/acre.

d. Organic residue.--Organic residues from Naalehu sites are listed in table 3. Generally residue decreased with depth. The 0- to 3-inch layer averaged 0.069 lb; the 3- to 6-inch layer, 0.037 lb; the 6- to 9-inch layer, 0.031 lb; and the 9- to 12-inch layer, 0.021 lb. Overall, the residue content ranged from 0.144 to 0.184 lb/ft^3, with a mean value of 0.157 lb/ft^3. These values are well within those measured for other cropped soils in this study.

5. Pakini Soil Series

a. Runoff.--Total runoff for dry runs on sites 41 and 42 (table 1) ranged from 1.67 inches (35 ft, 5.97 percent slope) to 2.45 inches (35 ft, 7.13 percent slope), with a four-plot average of 2.05 inches. Of the total applied rain (averaging 4.83 inches), 58 percent infiltrated into the soil during dry runs. Total runoff during wet runs on Pakini sites ranged from 3.23 to 3.38 inches, with a two-plot average of 3.31. In this case, only 37 percent of the rain infiltrated into the soil profile. As shown in table 11, runoff started during dry runs after a range of 9 to 11 min from beginning of rain, with a mean value of 10 min. The corresponding average time to initiate runoff during wet runs was 7.5 min. This indicates less difference between time of runoff for dry and wet runs than observed in other soils.

b. Soil moisture conditions.--As shown in table 2, antecedent dry run (field condition) moisture contents increased with depth. For example, the 0- to 3-inch increment had a mean value of 36.4 percent; the 18- to 24-inch increment, 52.1 percent. These values may be higher than expected for this relatively dry soil because of the abundance of natural rainfall during the winter these experiments were conducted. Soil moisture decreased with depth after dry runs as seen by average water contents in the same two increments, reaching values of 80 and 52.1 percent, respectively. Before wet runs, water contents in the 0- to 3-inch layer were lower than values obtained after dry runs the previous day, due to evaporation and downward water drainage, resulting in increased water in the deeper layers before wet runs.

c. Soil losses.--As shown in table 1, cumulative soil losses after dry runs ranged from 9.826 to 18.70 tons/acre with 14.14 tons/acre the mean value for four plots tested. Wet runs produced total soil losses of 16.08 and 11.77 tons/acre, with an almost identical average of 13.93 tons/acre for the two plots studied.

d. Organic residue.--Table 3 shows that organic residue collected on Pakini sites was the most abundant of all the soil series in this study. The mean value of residue from the four plots studied was 0.726 lb/ft^3 (15.78 tons/acre), with a range from 0.555 to 0.987 lb/ft^3. As was often the case in other soils, the upper 6 inches of Pakini soil contained the major portion of the residue. The average content in this layer was 0.520 lb compared with 0.206 lb for the underlying 6- to 12-inch layer.

VI. ANALYSIS AND DISCUSSION OF SOIL LOSS DATA

Soil losses incurred for each experimental site, as reported in section V, may be looked upon in view of the factors comprising the universal soil loss equation (*46*). The equation may be written as:

$$A = EI \times K \times LS \times C \times P$$

in which

A = soil loss in tons/acre;
EI = rainfall erosion index, which involves the total kinetic energy (E) of the test storm times its maximum 30-min intensity (I);
K = soil erodibility factor;
LS = combined length-slope factor;
C = cropping-management factor; and
P = erosion-control practice factor.

All terms of this equation are adequately explained elsewhere, for example, in USDA Handbook 282 (*46*). In this study, the soil loss, A, was determined experimentally with a rainfall simulator, which provided more or less uniform values of each applied storm. For the present simulator design, which utilized vee jet nozzles with defined drop-size distributions (*31*), the kinetic energy for applied rainfall is:

$$K.E.\text{/acre-in} = 800 \text{ ft-tons/acre-in}$$

for a rainfall intensity of 2.5 in/hr. Thus, the total energy applied in one storm would be

$$E = 800 \text{ ft-tons/acre-in} \times \text{total rainfall applied, inches} = \text{foot-tons/acre}$$

The intensity term is easily calculated for the simulator with controlled uniform intensity, as

$$I = \frac{\text{total rainfall applied, inches}}{\text{duration, minutes}} \times 60 \ \frac{\text{min}}{\text{hr}} = \text{in/hr}$$

Because it is customary to divide *EI* values by 100, the rainfall erosion index is calculated for each storm as:

$$EI = 480\ \frac{\text{ft-tons}}{\text{acre}} \times \frac{\text{minutes}}{\text{hour}} \times \frac{(\text{total rainfall applied, inches})}{\text{duration, minutes}}$$

$$= \frac{\text{foot-ton-inches}}{\text{acre-hours}} \qquad (1)$$

An underlying assumption in using equation 1 was that rainfall intensity did not exceed the mean intensity for 30 min or longer.

Analysis was made of the relatively few length and slope data in order to produce an independent *LS* factor. The results were inconclusive because of the limited data. Rather, the following relationship (*18*), based on mainland information, was used:

$$LS = \frac{\sum_{j=1}^{n} (S_j \lambda_j^{1.5} - S_j \lambda_{j-1}^{1.5})}{\lambda e (72.6)^{0.5}} \qquad (2)$$

in which

λ_j = distance (feet) from top of slope to lower end of any segment j;
λ_{j-1} = slope length (feet) above segment j;
λe = overall length of slope (feet) above segment j;
S_j = value of slope factor, S (see below) for segment j; and
$S = (0.043\ s^2 + 0.30\ s + 0.43)/6.613.$

where s = slope steepness in percent. This equation also had the advantage of being more applicable to nonuniform slopes, such as were found from the plot profiles made during the study. Therefore, equation 2 was programmed for the computer using exact slopes for 10-ft segments on all plots.

The cropping factor, *C*, was estimated from USDA Handbook 282 (*46*) with some modifications made for Hawaii conditions. Adjustments were made jointly by ARS, SCS, and University of Hawaii personnel after field inspection. Whenever possible, use was made of crop residue data reported in section V to estimate deviations of test sites from the reference fallow condition in which $C = 1$.

Finally, the value of the erosion-control practice factor, *P*, in all sites of this study, was assumed equal to 1 as all plots were laid out up and down slope, and no erosion control practices were evident on the plots.

With this background, the soil loss data will be discussed in two distinct ways. Cumulative data will be treated first and will be based on final results obtained for the whole storm. Second, will be incremental soil loss data for 30-min segments of each storm in which incremental *K* factors were computed from the soil loss and *EI* during each 30-min interval. The erodibility classes in table 4 will be used as a basis for describing the soils' susceptibility to erosion.

A. Soil Erodibility Analyses for Soils on the Island of Oahu

1. Molokai Soil Series

a. Full storm data analysis.--Table 5 shows the *K* factors measured on Molokai-A soil as a result of the first rainfall applications or dry runs. In arriving at the listed *C* factor from USDA Handbook 282 (*46*), it was assumed that the test sites received conventional tillage and that each resembled a seedbed prepared in the third or fourth year of corn (page 13, line 47, crop stage 1). The soil loss ratio thus obtained (0.80) was lowered slightly to allow for the incorporated organic residue reported in section V. Erodibility factors in table 5 show a great deal of variability even in adjacent plots of the same site. However, all values may be grouped in two categories. The first includes sites 1-6 with a mean value of 0.093, and the second includes sites 7-9 with a mean of 0.410. It may be recalled that experiments on the latter sites were preceded by drastic bulldozer preparation and are, therefore, considered to represent construction rather than normal sugarcane tillage conditions. Site 9 was rototilled and had a higher initial soil moisture content, the results of a rainulator test on site 8 4 days earlier. It is assumed that the overall mean of 0.186 represents an overestimate of dry run *K* values for agricultural areas on this soil.

K factors for wet runs on three Molokai-A sites, as shown separately in table 5, are considerably larger but reflect less variability than their counterparts for dry runs. The observed increases of two- to threefold are attributed to both increases in overland flow caused by larger volumes of runoff and to the weakening of soil surface aggregates (*27*). The latter occurred during the interim between dry and wet runs. Evidence for the first factor was presented in section V with earlier occurrence and larger amounts of runoff for wet than for dry runs on every site in this series. Evidence for the second factor was observed by visual observation of a soil surface "skin" layer consisting of failing crumbs or aggregates and by comparing incremental *K* values for the last 30 min of a dry run with the first 30 min of the wet run. A sudden rise in *K* value was noted during the latter period, which would not have been observed had the two tests been run in immediate succession.

The relative resistance of the soil to erosion by water is not surprising in view of their known high structural stabilities. Cagauan and Uehara (*10*) and El-Swaify (*15*) discussed aggregate stabilities of Oxisols in general, and Molokai soil in particular in relation to some other soil properties.

For calculations of erodibility on Molokai-B sites, the *C* factor was estimated as for Molokai-A but with an added adjustment because of the low content of organic residue. The test area was situated in an abandoned sugarcane field, which supported some volunteer sugarcane interspersed among vines and weeds. As shown in table 5, *K* factors obtained from dry runs ranged from 0.045 to 0.429, with a mean value of 0.193. The much higher value for site 15 may be explained by the soil filling, which was added to achieve a uniform slope, as well as by the occurrence of some natural rainfall during the period preceding the run (note water content data, section V). For wet runs, table 5 shows again a significant increase in *K* values, although not as much as was noted for Molokai-A sites. The wet run on site 15 produced a lower *K* value than the corresponding dry run, an observation that was contrary to all others on Oahu and can be explained by a sharp decrease in the amount of soil fill remaining after the first storm was applied.

Comparison between mean values obtained for agricultural sites on Molokai-A (excluding construction-type sites) and on Molokai-B soils indicates that the upper Molokai soil (B) has a considerably higher *K* factor. If the overall means are compared, it would be possible to assume that despite differences in their characteristics, the two soils may be looked upon as having *K* factors of 0.190 under "dry" conditions and 0.265 under "wet" conditions. The authors, however, do not believe that the two soils should be treated as one. Thus, depending on antecedent water contents at the occurrence of a storm, the Molokai-A soil series used for agricultural sites may be looked upon as being of very low or moderate erodibility and the Molokai-B soil as being of low or moderate erodibility (table 4).

b. Incremental changes in erodibility.--Changes in *K* factors for Molokai-A soil at 30-min intervals within experimental storms are shown in table 6. With few exceptions (for example, site 1, plot 1), a progressive increase in erodibility is obtained during dry runs. The extremely low values, obtained after 30 min of these runs, reflect the ineffectiveness of the first 1.25 inches of rainfall in inducing soil erosion on relatively dry soil. This is easily explained by the high initial infiltration capacity of the soil and the short duration of effective surface runoff during this interval. In sites 1-6, more representative of agricultural conditions, the second 1.25 inches of rainfall was only slightly more erosive than the first. In contrast, the second interval was extremely erosive on construction-type sites 7-9, producing *K* values that were close to and even occasionally exceeded mean values obtained for the whole storm (section *a*, above). Therefore, although erodibility calculations based on the second 30-min interval of a 2.5 in/hr rainstorm may underestimate soil erodibilities on sites used for agriculture, they may provide adequate estimates of erodibilities on those exposed for preconstruction preparations. During the third 30-min increment, erodibilities began to level off on all dry sites. Thereafter, a general slight increase in *K* values on agricultural sites and a slight decrease on construction-type sites was noted between this increment and the last. The last trend is probably due to the removal of loose fill or surface soils during the early part of the storm, with subsequent resistance of the consolidated underlying soil.

Data for wet runs, table 6, also reflect the leveling off of *K* values so that considerably less changes with progression of storm were noted during the various increments than for the dry runs. As a result, calculated factors during any one increment estimate well the factor for the overall storm as reported above. Therefore, experimental runs of shorter duration may still be sufficient for estimating adequate soil losses under wet antecedent conditions.

For Molokai-B soil, similar observations of incremental changes in *K* factors were noted (table 6). The higher erodibility of this soil, compared with agricultural sites on Molokai-A during a defined rainfall interval, was confirmed, particularly during dry runs.

2. Waipahu Soil Series

a. Full storm data analysis.--Table 5 shows the *K* factors measured on Waipahu soil as a result of the initial tests. The *C* factor of 0.75 was based on the assumption that cropping management for this sugarcane soil was similar to that for Molokai-A soil. Erodibility factors in table 5 are either nil or very low. However, some of the low data are not considered representative due

to the unusual condition of the soil surface. A large number of massive soil clods were present both as a result of plowing when the soil was not at optimum water content and following the installation of a pipeline 3 to 6 months earlier in that vicinity. Rototilling was not completely effective in preparing the sites to a more representative surface condition. Little runoff occurred, therefore, with much downslope subsurface flow noted in the plow layer. Only on site 11 was there sufficient natural rainfall prior to the run to allow more adequate surface preparation. Thus, although the overall mean *K* value for the dry runs is 0.010, the value of 0.029 is believed to be more representative. Based on either value, this soil may be considered of very low erodibility (table 4).

For wet runs on this soil, table 5 shows a wide range of variation among the three sites, the highest being that of site 11 on which, as stated above, rototilling had produced a less cloddy soil surface prior to the dry run. Although the overall mean value for the wet runs is 0.172, placing the soil in a low erodibility class, the value for site 11 alone is considerably higher (0.410) and would indicate the soil to be of moderately high erodibility (table 36). This is not surprising as it places the soil within the range reported in the literature for similar soils (*46*), that is, those with significant montmorillonite content such as Austin clay.

b. Incremental changes in erodibility.--Changes in *K* factors at 30-min intervals are indicated in table 6. For those tests in which runoff occurred, soil erodibility factors progressively increased during both dry and wet runs. This progressive increase in *K* factor is not manifest in site 11, believed to be most representative of this soil. This presumably occurred as a result of easier particle detachment accompanying water saturation of the soil in addition to more erosive overland flow as runoff volume increased. The unusual initial tilled condition of experimental locations on this soil was described previously. Obviously, the breakdown and slaking of large clods into detachable fragments had not been completed over the duration of the experimental period.

3. Wahiawa Soil Series

a. Full storm data analysis.--Table 5 shows close agreement among the four dry run *K* values of Wahiawa soil. The average is 0.085 compared with 0.093 for the "agricultural" type sites on Molokai-A and 0.193 for Molokai-B, both also Oxisols and previously classified as Low Humic Latosols. Yamamoto and Anderson (*50*) reported low splash erosion values for Low Humic Latosols. Because the experimental site for this soil had been freshly plowed and prepared for planting, the *C* factor used was 0.85. This represents an upward adjustment from USDA Handbook 282 (*46*, page 13, line 47, crop stage 1) because of the low organic residue found (table 3). Wet run *K* values for all sites are in good agreement, all being considerably higher than the dry values (table 5). Their mean value of 0.203 is somewhat low as compared with 0.211 for Molokai-A and for Molokai-B soil. This is in agreement with what would be expected from structural differences between the Molokai and Wahiawa soil (*10*). In the terms stated in table 4, the erodibility of Wahiawa soil would be considered as very low or moderate depending on antecedent moisture conditions.

b. Incremental changes in erodibility.--Table 6 shows that without exception erodibilities increased during both dry and wet runs. No erodibility was measured during the first 30 min of the dry runs and only scant values for the

next 30 min. Thus, 2.5 inches of rain produced practically no soil loss on Wahiawa soil under dry field conditions. This reflects the high infiltration rates of water into this well-aggregated soil. After 1 hr of experimental rain, *K* factors increased considerably. For wet runs, a more considerable increase was noted after only the first 30-min interval. According to Atkinson (*4*), two thirds of the rainfall on central Oahu, where this soil series prevails, occurs from cyclonic or kona storms. Therefore, more signifcant soil losses occur during the latter rather than the initial stages of these storms. It is this type storm that was simulated in these experiments. The remaining rain received in the area is either orographic or, to a minor extent, convective in origin and would not be expected to result in significant erosion, particularly on dry soil.

4. Lualualei Soil Series

a. *Full storm data analysis.*--Erodibilities of Lualualei soils are found in table 5. The *C* factor was calculated from USDA Handbook 282 (*46*, page 12, line 5, crop stage 1). The value 0.32 was multiplied by a factor of 1.5 because approximately one-third of the root clumps were removed during plot preparation. This yielded a factor of 0.48. Large, vertical cracks were apparent in the area before the sites were prepared. These were filled during plot preparation and appeared to completely close down as this montmorillinitic soil swelled upon wetting. Therefore, for soils at low moisture regime, the average erodibility factor was 0.255, which is classified as moderate according to table 4.

Wet run *K* factors average 0.311 as indicated by table 5. This value is also classified as moderate (table 4). Lopez and Bonnet (*26*) found that Vertisols had the lowest infiltration rates of the seven orders tested in Puerto Rico, which suggested the highest erodibilities. The *K* factor for Austin clay, a famed Texas Vertisol listed in USDA Handbook 282 (*46*), is 0.29, which corresponds closely to the value reported here, both classifying as moderate erodibility.

b. *Incremental changes in erodibility.*--Changes in erodibility during storms are indicated in table 6. Without exception, increases occur periodically during the initial rainfall application. From low values during the first 30-min increment, steep increases occur throughout each succeeding interval in the dry run. However, wet run incremental values do not exceed the final incremental values of the respective dry runs. Possibly, the weak aggregation of this soil allows rapid wetting of structural units and subsequent early arrival of steady state infiltration and runoff. The swelling of the montmorillonite clay prevailing in this soil contributes to easier breakdown of wetted structural units. Swelling produces a secondary effect on infiltration rates by sealing surfaces and closing initial soil cracks.

5. Waikane Soil Series

a. *Full storm data analysis.*--In calculating the erodibility of Waikane soil during dry runs (table 5), the *C* factor (0.80) was taken directly from USDA Handbook 282 (*46*, page 13, line 48, crop stage 1). The average *K* factor was 0.011, which is classified as very low erodibility (table 4). This average figure reflects two distinct soil locations. The first (sites 24, 25) possessed

a rather cloddy soil surface condition, resulting from plowing at less than optimum moisture. For the second (site 23), soil surface conditions were less cloddy. In the manner noted previously for Waipahu soils, therefore, the factor of 0.011 must be considered nonrepresentative of the true soil erodibility at either location. On site 23, no soil loss was measured after more than 9 inches of rain, indicating stable surface structure. On sites 24, and 25, on the other hand, signifcant runoff and erosion were measured, which indicated appreciable breakdown of surface clods. Lopez and Bonnet (*26*) found high infiltration rates, and, subsequently, Barnett et al. (*6*) similarly reported low erodibility for an Ultisol in Puerto Rico (Humatas clay, a Typic Tropohumult, had a *K* factor of 0.004).

Erodibility values for wet runs (table 5) indicate the same wide differences in magnitude between the Waikane soils at the first site compared with those of the latter sites. The average erodibility was 0.090, which, although considerably higher than that based on dry runs, still is classified as "very low" (table 4). For the latter two sites, the mean value of 0.135 would be classified as "low."

b. Incremental changes in erodibility.--Table 6 shows that no soil erodibility was recorded after 2.5 inches of rain, reflecting no soil loss during the initial hour of dry runs on all sites. Thereafter, *K* factors increased during each succeeding 30-min period. This increase was less during wet runs, particularly after the first 30-min increment. Apparently, the value obtained during the final wet run increment represents a relatively steady soil loss rate under the present rainfall intensity.

6. Plantation Roads

a. Full storm data analysis.--An estimated 9 to 15 percent of plantation land in Hawaii is occupied by roads. Table 5 shows erodiblities of Molokai and Wahiawa soils employed as sugarcane and pineapple plantation roads. The employed *C* factor of 0.925 represents the average of 0.85 (selected for Molokai-B and Wahiawa soils) and 1.0 (the maximum value defined for a site left fallow for 2 years and tilled as necessary to prevent plant growth or serious crusting). The departure from 1.0 was deemed necessary because the roads underwent traffic disturbance and were not tilled in recent years.

Both plantation roads exhibit similar erodibilities under the initial rainstorm (table 5). According to the arbitrary standards of table 4, both are considered moderately erodible. It may be recalled that other Molokai-B and Wahiawa soils are rated as low and as very low, respectively. Therefore, plantation roads apparently present a more significant erosion hazard than do comparable areas in actual cultivated fields.

Table 5 indicates the erodibility of the pineapple plantation road (Wahiawa soil) during wet runs was twice that of the sugarcane road (Molokai-B soil). This classifies the former as low and the latter as moderately high erodibility (table 4). Several factors are believed to have contributed to these major differences. The sugarcane road had not been as heavily used prior to the experiments as was the pineapple road, so that structural breakdown in the latter occurred more readily. This was particularly enhanced by the lower water content in this site (table 2), which allowed more pulverization by vehicular traffic. Furthermore, oil from motor vehicles was more visible on the sugarcane road surface. This perhaps imparted a hydrophobic character to the soil, minimized aggregate wetting, and reduced subsequent breakdown and detachment.

b. Incremental changes in erodibility.--Table 6 indicates that *K* factors for the sugar plantation road decreased incrementally during the dry run. Among the reasons mentioned above for the relatively low erodibility on this site is that the presence of oil on the road may not have stabilized the uppermost part of the soil surface as efficiently as it did the underlying soil bed. The surface, therefore, was more easily detached than the subsurface. No definite conclusion may be reached as to the effect of antecedent water content on this road. On the other hand, erodibilities from the pineapple road increased periodically during the dry run. Recent heavy vehicular traffic, as stated above, was effective in producing an abundance of detachable soil material, the removal of which reached a peak by the middle of the wet run.

Note that, on both roads, significant erodibilities were obtained even for the first 30-min increment of the experiment. This reflects both the short time necessary for initiation of runoff (table 11) and the presence of rather loose fragments at the soil surface overlying a relatively dense, compacted roadbed.

B. Soil Erodibility Analyses for Soils on the Island of Hawaii

1. Kukaiau Soil Series

a. Full storm data analysis.--Table 5 shows erodibilities for the initial storms. The *C* factor calculated for this soil was the same as for Molokai-A soil on Oahu because both soils have similar cropping practices. Fairly close agreement is noted between erodibilities of soils on adjacent plots. It should be recalled that all sites on the island of Hawaii were subjected to experimental storms on plots of only 35-ft length. Some of the higher variability obtained on the agricultural sites of Molokai-A soil was due to the fact that higher erodibilities were generally noted for longer plots. This could indicate the need for use of different soil loss ratios (*LS* factors) on Hawaii soils.

The overall average *K* factor for dry runs on this soil was 0.124. Table 5 indicates less agreement between values of erodibilities for adjacent plots during wet than during dry runs. However, a definite increase in the average factor to 0.216 is confirmed. Thus, Kukaiau soil is classified (table 4) as being of low or moderate erodibility, depending on antecedent moisture conditions.

At first glance, it may be difficult to reconcile similar erodibilities in a volcanic ash soil (Kukaiau) and an aggregated nonash soil (such as Molokai-A "agricultural" sites). However, Kukaiau has a unique property, shared by many volcanic ash soils, of dehydrating irreversibly into fine sand-sized aggregates (*38*). Such change is particularly enhanced to varying degrees by forest clearing, tillage, and cultivation. Similarities in certain physical properties, therefore, may exist between this and the Oxisol. Further studies on inherent properties of these soils in relation to soil erodibility are now in progress. Barnett et al. (*6*) emphasized the importance of aggregate stability as a reason for the relatively low erodibilities of two Puerto Rico Inceptisols (0.017 for Juncos clay and 0.113 for Pandura loam); however, these soils were not formed from volcanic ash. Furthermore, test conditions were not similar in the Puerto Rico and Hawaii rainfall simulation studies. In the former, a 60-min storm of 2.5 in/hr intensity was followed by a 10-min period without rain, and then a 5 in/hr rainfall intensity, for 60 min. As seen from data presented in this report so far, a 10-min drying period between storms was probably unlikely to allow as much change in aggregated soils as might occur over 16 to 24 hr, the

period elapsing between dry and wet runs in this study. Note that Yamamoto and Anderson (*50*) found ash soils on Oahu to be most subject to splash erosion.

b. Incremental changes in erodibility.--*K* factors generally increased steadily during dry runs although several anomalies are evident (table 6). As previously observed, erodibilities are low during the first 30-min period of the dry run, but corresponding wet run values are much higher. In general, erodibilities increased during successive 30-min wet run periods. However, the data are insufficient to indicate the stage at which a plateau is reached within applied storms.

2. Hilo Soil Series

a. Full storm data analysis.--Table 5 shows reasonably close agreement among the four erodibility factors measured for the initial storms. Based on similarities in management practices between Hilo and Molokai-B test sites, the *C* factor for this soil was also chosen as 0.85. The average *K* factor for the dry run was 0.084, which is almost the same as the value obtained for wet runs (0.072) as indicated in table 5. Both are in the very low erodibility class, and their similarity suggests a relatively stable surface condition with little erosive effect due to the initial storm and the subsequent time lags before the wet run. This is explained by the natural, very high antecedent moisture conditions (table 2) prevailing in Typic Hydrandepts at all times. The soil indeed appears to be in identical condition under both storms, perhaps due to being under a steady state condition with respect to runoff and erosion under relatively high rates of rainfall. Although a fraction of the soil may form discrete aggregates upon drying, the 120 to 180 inches of natural annual rainfall probably ensures that the majority of the soil mass remains in the natural "gel" form. However, the situation is not as beneficial to agriculture as first appears. Hilo soil has a porosity of 85 to 90 percent, which indicates that the relatively small sediment weights recovered during tests represent fairly large field volumes of soil. The two Puerto Rico Inceptisols investigated by Barnett et al. (*6*) have *K* factors of 0.017 and 0.113, which bracket the value found for Hilo silty clay loam.

Opportunity presented itself to study natural erosion in a semiquantitative manner after a 13.98-inch rainstorm of approximately 30 hr duration struck the Hamakua coast of the island of Hawaii on November 11 and 12, 1973. Such a storm may be expected every other year. Surface grasses and weeds had been cleared for two plots on site 35. Troughs, outlet pipes, and collection pits were functional when the storm occurred so that removed sediment was collected. The collection pit from plot 2 had a mound of fine sandlike sediment approximately 25 inches deep, 33 inches long, and 26 inches wide. Erosion patterns developed over the whole surface of the plot and in a massive rill 7 to 9 inches wide and 3 to 7 inches deep. Plot 1 had a similar major rill 5 to 13 inches wide and 4 to 7 inches deep on the upper third of the plot, which broadened out to form a delta at the bottom of the plot where some remaining vegetation curtailed erosion. The pit from plot 1 was lined with shiny clay, and 12 inches of standing water was still present several hours after the storm; however, sediment volume was considerably less than that observed in the pit of plot 2. In contrast, erosion was not visible on the untilled area covered with vegetation.

b. Incremental changes in erodibility.--Table 6 shows that only the first 30-min intervals during dry runs have lower erodibility factors than following increments. Thereafter, *K* factors rapidly level off and become rather constant. The same general trend seems to exist for wet runs. This supports the above explanation (section *a*, above) that this Typic Hydrandept is indeed in a steady state with relatively high rates of rainfall. However, rainstorms of higher intensity than employed here may be expected to disrupt this steady state if they continue for sufficiently long durations.

3. Kawaihae Soil Series

a. Full storm analysis.--Erodibility factors in table 5 and 6 were calculated using a *C* factor of 0.60, which is the value noted in USDA Handbook 282 (*46*, page 12, line 6, crop stage 1) adjusted higher because one-third of the original root clumps were removed. The average *K* factor from all sites for all dry runs in 0.293. However, the authors believe that data from site 37 should be eliminated from the overall average as the experimental storm lasted only 58 min on that site. An alternative value of 0.364 is then obtained. The 0.342 obtained for wet runs indicates that this soil is nearly equally susceptible to erosion under dry and wet antecedent moisture conditions. The soil is, therefore, classified as being of "moderately high" erodibility (table 4). This was confirmed also by visual examination of plot surfaces after application of simulated storms. Harrow marks, initially produced during plot preparation, had virtually disappeared, which indicated uniform soil removal by erosion to a significant soil depth. It must be emphasized that the differences between dry and wet run *K* factors would probably have been more pronounced were it not for the fact that antecedent moisture conditions before dry runs were unusually high for this soil (table 2). On the other hand, the similarity between the two values may merely reflect the absence of aggregation in this soil.

b. Incremental changes in erodibility.--*K* factors for dry runs were, as for other soils, lowest during the first 30-min increment and then generally increased with time within the run. Initial wet runs values were somewhat lower than those obtained in the final increment of the dry run but appeared to stabilize at slightly higher values after 30 min of rainfall application.

Although Kawaihae soils receive relatively low natural rainfall (10 inches at the study site annually), much of this is received during cyclonic or "kona" storms. The sparseness of vegetation and unstructured nature of the soil may lead to heavy soil losses during these infrequent rainfall events. Based on its apparent texture, this soil may be compared with Marshall silt loam (*K* factor, 0.33) or Fayette silt loam (*K* factor, 0.38), both listed in USDA Handbook 282 (*46*). The relatively high erodibility of this soil is in agreement with the findings of Yamamoto and Anderson (*50*) who reported high splash erodibility for volcanic ash soils on Oahu.

4. Naalehu Soil Series

a. Full storm data analysis.--Erodibility factors for dry runs compare favorably for duplicate plots on the two sites tested (table 5). Because of similarities in management of this sugarcane soil to Molokai-A soil on Oahu, the *C* factor was also chosen as 0.75. An average *K* factor of 0.160 indicates low

erodibility for Naalehu soil during initial storms. For wet runs (table 5), the value increased to 0.256, which signifies "moderate" erodibility. However, because some of the exposed stones and cobbles (down to 2-inch diameter) were removed from the plot surface, the *K* factors are probably slightly higher than in the natural condition. If, as practiced by SCS[5], the *K* factor is reduced by one numerical class, the descriptive erodibility class to which the soil has been assigned, according to table 4, would remain unchanged. It is of interest to recall that Barnett et al. (*6*) found much lower erodibility values for two Inceptisols studied in Puerto Rico, indicating that the Andepts of Hawaii are different from the Tropepts of Puerto Rico.

b. Incremental changes in erodibility.--As was the case for other soils, low erodibility factors were found for the first 30-min periods, which increased rapidly during the next two increments of the dry runs (table 6). However, a general slight decrease of *K* factors was noted during the last 30-min increment. The initial *K* values during the wet run (table 6) were considerably higher than their counterparts in the dry run, reaching uniform values during the latter two 30-min periods.

As stated in section IV, these tests were carried out on a shallow variant of the Naalehu soil; the true series was a deeper soil and probably less erodible.

5. Pakini Soil Series

a. Full storm data analysis.--The highest erodibility factors obtained in this study were found for the four plots tested during dry runs on this soil (table 5). Because the vegetation on Pakini soil was similar to that on Lualualei soil (both being in meadow), the same reasoning was used to obtain the present *C* factor. The value of 0.32 obtained from USDA Handbook 282 (*46*, page 12, line 5, crop stage 1) was multiplied by 1.5, because approximately one-third of the root clumps were removed during plot preparation, thus yielding 0.48. The average dry run *K* factor was 0.602, which is classified as "very high," whereas the wet run value was 0.512 (table 5), which is classified as high erodibility (table 4). The lower *K* value obtained during the wet run is surprising for this relatively dry soil. Reference to table 2 indicates that a gain of about 25 percent was achieved in antecedent water content between dry and wet runs. Differences in *K* values may, therefore, be due to the removal of the most loosened soil material produced by site preparation during the initial storm. In any case, the values for wet and dry runs are not widely different and indicate that absence of aggregation may be responsible for the minimal effects due to the initial storm and subsequent period of soaking.

The high *K* values reported here are in direct contrast to values for other Inceptisols reported for other soils both in this study and earlier by Barnett et al. (*6*) for Puerto Rico soils. The susceptibility of certain volcanic ash soils to splash erosion was reported by Yamamoto and Anderson (*50*) and was confirmed for this also based on visual evidence of the plot surface. Uniformity of soil loss was noted by even disappearance of harrow marks at the conclusion of the dry run.

---

[5]Grant, K. E. (Administrator). Soil erodibility and soil loss tolerance factors in the universal soil loss equation. U.S. Dept. Agr., Soil Conserv. Serv. (Inserv. Memo.) Advisory SOILS-6, 7 pp.

Several interesting observations were made during the erodibility tests on Pakini soil. First, although our main concern was water erosivity, the bare soil was observed to undergo significant wind erosion. South Point, on the island of Hawaii, is a high-wind area so that more precautions were needed to prevent wind interference with rain simulation. These included conducting the experiments in the early morning hours and constructing a windbreak mounted on trucks. Fortunately, this soil is used for grazing rather than plowed for crops. Second, Pakini soils are considered to have high permeabilities (6.3 to 20 in/hr) according to Sato et al. (*35*). This was not supported by the rainfall simulation tests in which the final infiltration rate was approximately 1 in/hr. Lastly, by comparison with other literature data, Pakini very fine sandy loam acts erosionally more like a silt loam. As an example, USDA Handbook 282 (*46*) lists Dunkirk silt loam and Keene silt loam with K factors of 0.69 and 0.48, respectively, which are reasonably close to the dry and wet run values of Pakini soil, respectively.

b. Incremental changes in erodibility.--Table 6 shows that the erodibilites increased markedly after the initial increment during dry runs even though the initial K factors were relatively high. In several instances, decreases in K values were noted during the last increment, thus confirming the statement above concerning the explanation of lower K values during the wet run. Whereas the first 30-min erodibilities in the wet run are higher than their dry counterparts, the succeeding values are generally lower than the corresponding dry run factors. As in the dry run, the 90- to 120-min erodibilities decreased significantly from the preceding value.

VII. HYDROLOGIC DATA ANALYSIS AND DISCUSSION

A. Predicting Runoff Initiation Times Under Field Conditions In Tropical (Hawaii) Soils

The time runoff starts during a certain rainstorm depends upon the basic water conducting and retaining properties of soil (under unsaturated and saturated conditions), the antecedent soil water content, and the intensities of the rainstorm. Knowledge of runoff initiation times is important for accurate assessment of erosional hazards and application of simple models to describe rainfall-runoff relationships on a watershed. Use of the universal soil loss equation (*45*, *46*) for predicting individual-storm or short-term soil erosion would require a knowledge of runoff and erosion. When runoff initiation times are small, such as for heavy rainstorms on many soils of the mainland United States or on many other initially wet soils, deletion of the prerunoff portion of the storm may not cause much error in the calculations of soil loss by the above equation. However, as shown in table 11, runoff initiation times may be appreciable on many (generally very permeable) tropical and subtropical soils at field capacity or drier conditions. The field rain-simulation studies presented in previous sections indicated that these times lasted as long as 60 to 80 min on some soils for a rainstorm of 2.5 in/hr intensity. Leaving the prerunoff (nonerosive) portion of such a rainstorm in the computation of the energy-intensity (EI) factor for use in the soil loss equation, would introduce a great discrepancy (*24*).

The purpose of this section is to examine the runoff initiation times in relation to antecedent soil-water status, as measured in the present studies.

A simple equation based on the well-known Green-Ampt approach (*19*, *29*, *41*) is tested for predicting the runoff initiation times under field situations.

1. Theoretical

In the process of rain infiltration, there is at least a brief initial period when all the rainfall infiltrates. During this period, the water content of the soil surface increases with time, abruptly first and more gradually later until a steady value is reached (*3*). When the rainfall intensity is higher than the saturated conductivity of the soil, the surface finally becomes saturated with water. The moment of surface saturation is also the time of runoff initiation. All the high-intensity rainfall can no longer be infiltrated, because the hydraulic conductivity at the soil surface reaches the maximum limit, and the hydraulic gradients in the wetted soil zone continue to decrease with time. At this time of runoff initiation, the rainfall intensity may be related to soil properties by the following Green-Ampt type equation (*29*, *41*):

$$I = K_s \{1 + Y(\theta_s - \theta_i)/q\} \tag{3}$$

in which

I = rainfall intensity,
K_s = near-saturated hydraulic conductivity of the soil,
Y = soil-water pressure head at the wetting front,
θ_s = the volumetric water content of the soil at field saturation,
θ_i = initial soil water content, and
q = cumulative infiltration.

For a constant rainfall intensity I, the cumulative infiltration q until the time of runoff initiation, t_0, is equal to the product It_0. Substituting this relationship in equation 1 and solving for t_0 yields

$$t_0 = K_s\, Y(\theta_s - \theta_i)/\{I(I-K_s)\} \tag{4}$$

This equation thus predicts a linear relationship between t_0 and the soil saturation deficit $(\theta_s - \theta_i)$ for a given rainfall rate, provided the wetting-front suction is not appreciably changed by a change of the initial water content θ_i. This latter condition would normally be satisfied for initial water contents at field capacity and lower.

Equation 4 is valid only for a homogeneous soil of uniform initial water content with depth. Under field situations, these conditions would seldom hold exactly. However, until the time of runoff initiation, the water infiltration may still be within the upper foot of soil, which may be assumed uniform in itself, especially if it represents the plowed layer of an agricultural soil. Similarly, an average of the initial water content distribution in this layer may be used as the uniform initial value for the purpose of equation 4.

2. Experimental

Examination of the runoff initiation time-antecedent soil water status relationships and tests of equation 4 were done on the data collected during the

rain simulator studies of soil erodibility discussed previously in this report. The relevant data of applied rainfall, runoff initiation time, and initial and final soil water contents were presented in sections V, X (Appendix), and V, respectively. Bulk densities for different soils, sites, and plots are presented in table 7.

As previously mentioned, the data were collected from 8 to 10 different sites for two of the soils, and from 2 to 3 sites for the rest. To test equation 4, the data from all the sites, plots, and runs on a given soil series were pooled. Therefore, considerable spatial variability is built into the data. Dry and wet runs are explained in section III. The reader is also referred to section III for detailed description of the rainfall simulator and intensities, plot sizes, slopes, and plot preparation.

The runoff initiation time was obtained as an average from visual observation of the inception of water accumulation on the soil surface and from noting the time runoff was first received in a collection pit located below the lower edge of each plot. The average rainfall application rate was measured separately for each plot in each run. This average was for the complete run, which normally lasted 2 hours. Because a uniform rainfall application was assumed, no separate measurement was made for the rainfall applied until the time of runoff initiation, which is our present interest. It may be recalled that the average rainfall application rate, I, varied somewhat from the intended rate of 2.5 in/hr in different runs on any given soil. Those rates can be inferred from total rainfall and time data presented in section V.

Initial and final water contents for each plot are presented in section V. The initial soil-water content distribution in the profile was measured by gravimetric sampling in different layers from 0- to 3-, 3- to 6-, 6- to 12-, 12- to 18-, and 18- to 24-inch depths before each run. Final soil-water contents were similarly determined after each run. The sampling was generally completed within half an hour after the end of the rainfall application. These final values may have been underestimated because of some time delay. From these values, weighted-average water contents in the top 6 and 12 inches of soil were computed. These averages were multiplied by bulk density values of the surface layer (determined separately) to obtain the volumetric soil-water contents θ_s and θ_i for use in equation 4. By actual comparison, the average ($\theta_s - \theta_i$) value for the top 6-inch layer was more closely related to the runoff initiation time t_0 in 7 of the 10 soils tested than the average value for the top 12-inch layer. The 6-inch average was, therefore, chosen as a basis for all the soils.

3. Results and Discussion

The measured runoff initiation times are plotted against the saturation deficit, $\theta_s - \theta_i$, for all 10 soils of the study. Figure 4 gives the data for the two soils where a large number of experiments were conducted. Figure 4, *A*, is for Molokai soil (a Typic Torrox) for which there are data for 27 different runs from 10 different locations. There is an appreciable scatter in the data points and a significant variation in soil bulk density (B.D.)(0.85 to 1.26 g/cm^3) at different sites. Yet, interestingly, a majority of the data points do tend to fall along a straight line, as indicated by a solid line drawn to illustrate the theoretically predicted relationship.

Figure 4, *B*, is for Kukaiau soil series (a Hydric Dystrandept), which tends to exhibit a swelling-shrinking behavior in marked contrast to the Molokai series described above. More scatter is in the measured data than was observed in

the Molokai soil, although the variation in B.D. values at eight different sites is of nearly the same magnitude as for that of the Molokai. Factors other than B.D. may have also caused variation observed in the data. Some possible reasons are discussed farther on in this section. Even in the Kukaiau soil, a majority of data points are fairly well described by a linear relationship between the runoff initiation time and the soil's saturation deficit.

Figure 5, *A* to *D*, shows data for the four remaining soils from the island of Oahu where four to six runs were made on two or three different sites. B.D. variation and the number of investigated sites are given in the figure for each soil. The data for Waipahu (a Vertic Ustropept) and Lualualei (a Typic Chromustert) soils exhibit fairly good linear relationships, whereas those for the Waikane (a Humoxic Tropohumult) and Wahiawa (a Tropeptic Eutrustox) do not show clear trends.

Figure 6, *A* to *D*, shows data for the four remaining soils from the island of Hawaii where six to eight runs were made on two different sites. The data for Kawaihae (a Ustollic Camborthid), Pakini (an Entic Eutrandept), and Naalehu (a Lithic Eutrandept) soils are fairly well described by linear relationships, whereas those for Hilo (a Typic Hydrandept) soil show too much scatter.

Among the many factors that could have caused variability in the data and, possibly, deviations from the Green-Ampt predictions are natural soil variability between different sites of any given soil series, roughness and crusting of the soil surface before the rainfall application, variation in rainfall intensity of the simulator within each run, slope, errors in measuring the runoff initiation time, and errors in determining average final and initial water contents. When the results presented above are examined in this light, it may be concluded that equation 4 does a fair job, overall, in describing the experimental data. In Molokai and Kukaiau soils, for which there were a large number of data points, the predicted linear relationship between runoff initiation time and the soil's saturation deficit is fairly well illustrated. In other soils, for which there were a small number of data points, the predicted linear relationship appears to

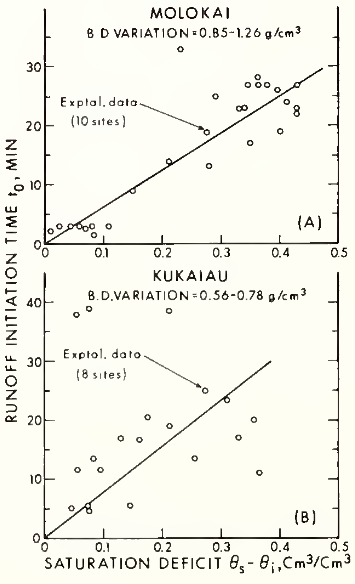


Figure 4.--Runoff initiation time as a function of antecedent soil-water saturation deficit measured in 20 or 27 runs at 8 or 10 sites of Molokai and Kukaiau soil series. B.D. = bulk density variation between sites.

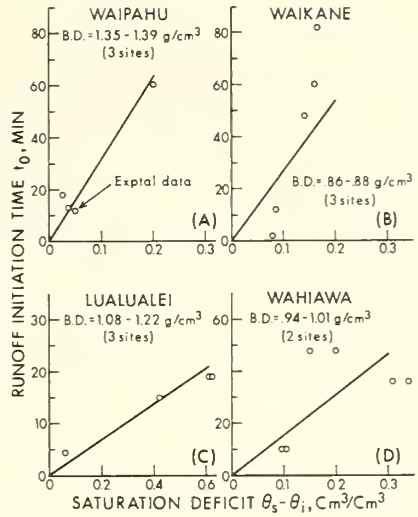


Figure 5.--Runoff initiation time as a function of antecedent soil-water saturation deficit measured at 2 to 3 sites of 4 different soil series on the island of Oahu. B.D. = bulk density variation between sites.

hold in some soils, but is not so well illustrated in others because of considerable scatter in the data. In general, the simple equation 4 is useful for approximate prediction of runoff initiation times on the uncropped soils used in this study. For practical application, equation 4 requires measurement of a relatively simple soil variable (initial water content) once the linear relationship has been defined. Subsequently, one may be able to make intelligent estimates of the effective erosion fraction of a storm and to determine the extent to which the erosion hazard depends on the prevailing water content of soil. This is important because erodibilities of Hawaii soils generally showed strong dependence on antecedent soil water contents, a matter that necessitated the use of two different *K* factors (dry and wet) for most soils (section VI).

B. Infiltration Characteristics Governing Runoff Hydrographs

The rates and amounts of runoff during a given rainstorm are very important factors in determining the rates and amounts of soil loss by erosion. The runoff hydrograph is, in turn, determined by the infiltration characteristics of a soil and the prevailing initial and boundary conditions. The purpose of this subsection is to analyze the infiltration data collected during the present study to deduce, as far as possible, the infiltration characteristics of different soils. A simple empirical-physical model is applied to describe infiltration rates, and its utility is evaluated. Because the field rain simulation studies were conducted with the primary objective of measuring soil erodibilities, not all the parameters for a detailed physical characterization of infiltration were measured.

1. The Infiltration Model

The simple approach of Green and Ampt (*19*) for describing water infiltration into a soil has recently been revived and successively applied to several

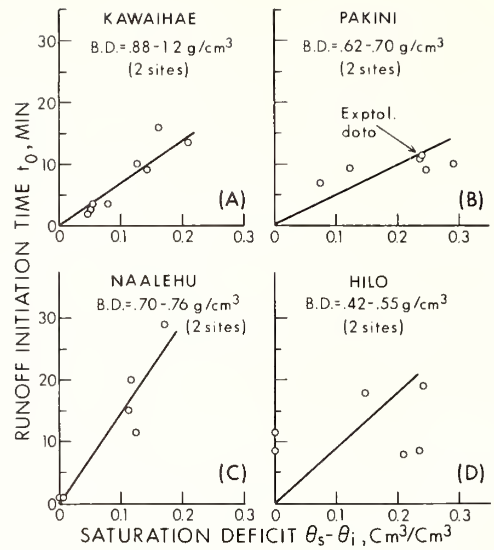


Figure 6.--Runoff initiation time as a function of antecedent soil-water saturation deficit measured at 2 sites of 4 different soil series of the island of Hawaii. B.D. = bulk density variation between sites.

specialized problems (*2*, *12*, *21*, *29*). The Green-Ampt equations for free water (or ponded water) infiltration rate into a uniform soil may be written as

$$\upsilon_0 = \bar{K} + \bar{K}Y(\bar{\theta} - \theta_i)/q \qquad (5)$$

where

υ_0 = time-dependent infiltration rate at the soil surface at any given time;
$\bar{K}$ = hydraulic conductivity of the transmission zone (assumed constant);
Y = effective soil-water pressure head at the wetting front;
$\bar{\theta}$ = volumetric soil-water content of the transmission zone;
θ_i = initial soil-water content; and
q = cumulative inflow volume at that time.

In equation 5, the infiltration rate, υ_0, is not explicitly shown as a function of time, but time is implicitly a function of cumulative inflow volume.

Equation 5 can be adopted for use in layered soils (*12*). To apply the equation, the soil parameters $\bar{K}$, Y, $\bar{\theta}$, and θ_i are required for each horizon. All these parameters were not measured in the rain-simulation study because this analysis was not originally intended. Therefore, a somewhat empirical form of equation 5 will be tried. It may be written as

$$\upsilon_0 = A + B/q \qquad (6)$$

where A and B are constants for a given soil and prevailing conditions. This type of relationship may hold in certain layered soils in which the subsoil has much lower permeability than the topsoil (*12*).

Equation 6 was fitted to field infiltration data collected in the rain simulation studies, using a least-squares approach. The adequacy of fit and variability in values of the constants A and B were then examined.

2. Results and Discussion

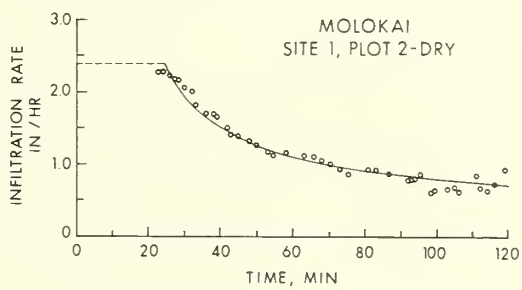
The detailed infiltration rates versus time for all soils, sites, and plots are presented in table 13. Table 8, shows the infiltration rates measured at the end of the runs, whether steady state was achieved, constants for fitting equation 6 to the data, the nature of fits, as well as comments on problems encountered during runs where applicable. Examples of the data and values predicted by equation 6 for eight selected cases are depicted in figures 7 to 10.

Achievement of steady state was judged visually based on plots of infiltration rate against time (Appendix). The data in table 8 indicate that infiltration of applied rain into a "dry" soil profile did not reach the steady state for any of the soils in the initial 2-hour period. Even for subsequent rainstorms, or wet runs, steady state was achieved only during two-thirds of the tests. There do not seem be consistent differences between soils in this regard.

The steady state infiltration rates were high in Waipahu (1.6 in/hr), Waikane (1.14 in/hr), and Kukaiau (0.8 to 1.02 in/hr) soils. They were moderately high in Pakini soil (0.61 to 0.82 in/hr), and rather moderate in Molokai (0.31 to 0.88 in/hr), Hilo (0.26 to 0.462 in/hr), Kawaihae (0.40 in/hr), and Naalehu (0.26 to 0.30 in/hr). In Lualualei soil, the steady infiltration rate was low (0.09 in/hr).

Selected cases of measured and predicted transient infiltration rates for three different soils presented in figures 7 to 10 showed a range of from good to poor fits of equation 6.

Figure 7 gives data for dry runs on two sites of Molokai soils where the fits are good. Figure 8 shows data from a dry and a wet run on the same plot at one of the sites of Molokai soil, where the fits are fair. Figure 9 depicts the data from a dry and a wet run on Waikane soil, where the fits are fair to poor. Examples of a dry and wet run on Kukaiau soil, shown in figure 10, are fair to good.



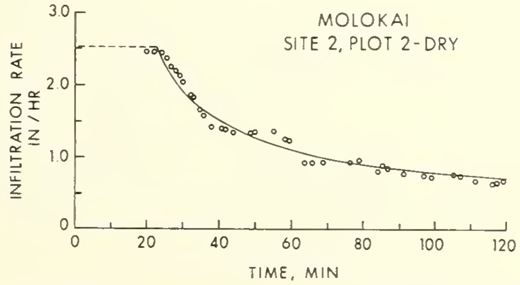


Figure 7.--Measured (circles) and predicted (curve) infiltration rates versus time for two selected sites of Molokai soil.

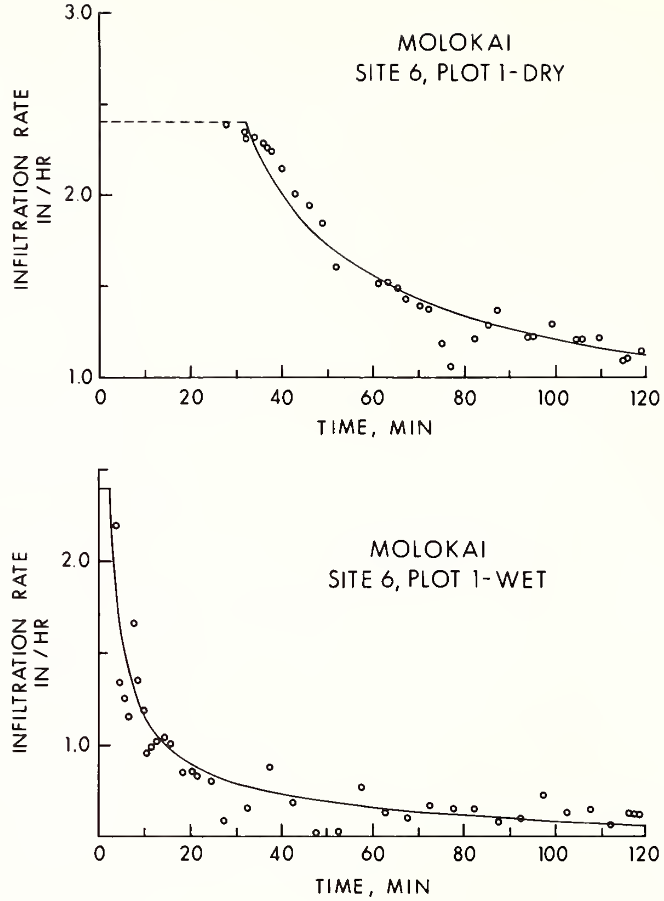


Figure 8.--Measured (circles) and predicted (curve) infiltration rates during dry and wet runs on a site of Molokai soil.

As mentioned earlier, table 8 gives the constants for fitting equation 6 to the measured infiltration rates for all the runs on different sites and soils. The nature of fit, whether good, fair, or poor, is indicated in each case. In several cases, the poor fit was a result of errors and scatter in the data due to machine breakdowns and water pressure fluctuations causing variable water application rates during the runs. In general, equation 6 provides reasonably acceptable fits to the field data for any given run. However, there is an appreciable variation in the values of coefficients fitted for different runs and different sites. Strictly, one may have to distinguish between different sites of a given soil, due to natural variation among them.

For practical predication of infiltration using equation 6, average values of the parameters A and B for the different soil series are listed in table 9. For each series, a dry run average, a wet run average, and an overall average value are tabulated. Parameters for runs in which data showed poor fits of equation 6 were not included in the averaging. Table 9 indicates that for parameter A some differences between the dry-run and wet-run average are not consistent among the different soils. Comparing equation 5 and 6, this parameter would not be expected to depend upon initial water content. Averaging over all the runs would, thus, provide the best estimate for the value of A. For parameter B, table 9 indicates that the dry-run averages are larger than the wet-run averages for all soils except Hilo. Initial water-content data presented in table 2

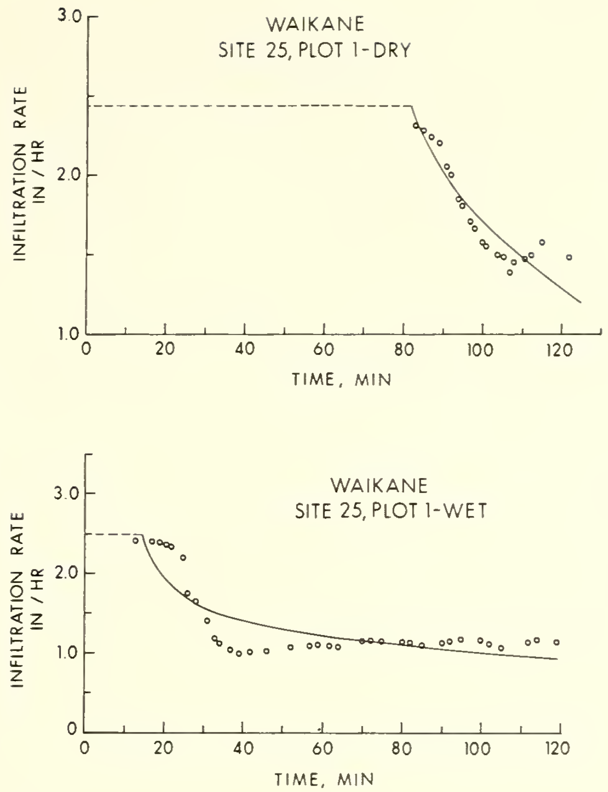


Figure 9.--Measured (circles) and predicted (curve) infiltration rates during dry and wet runs on a site of Waikane soil.

indicate that Hilo soil was, in fact, wetter before the so-called "dry run" than before the "wet run" (possibly due to occurrence of natural rainfall preceding the dry run). This may explain the discrepancy for Hilo soil. Again, a comparison of equation 6 with the theoretical equation 5 indicates that the parameter *B* does depend upon the initial water content. Therefore, different values should be used for dry and wet runs for parameter *B*. Detailed information on parameters of equation 5, however, should be required for more refined predictions of the infiltration and, therefore, runoff under various storms.

VII. SUMMARY AND CONCLUSIONS

1. Soil losses and calculated erodibilities from the initial storms (dry runs) were generally lower than those resulting from the subsequent storms (wet runs). *K* factors generally increased during dry runs and reached constant values during the latter part of the wet runs. This indicates that the linear relationship between soil loss and applied *EI* units holds reasonably well once the soil moisture conditions reached a steady state. However, three volcanic ash soils (Hilo, Kawaihae, and Pakini) had similar *K* values for wet and dry runs. For the Hilo soil, this is due to its high antecedent moisture content under natural field conditions; for the other two soils, the absence of strongly developed structure results in more rapid initial wetting or soil detachment. Nevertheless, the need to take into account antecedent moisture conditions for soil loss

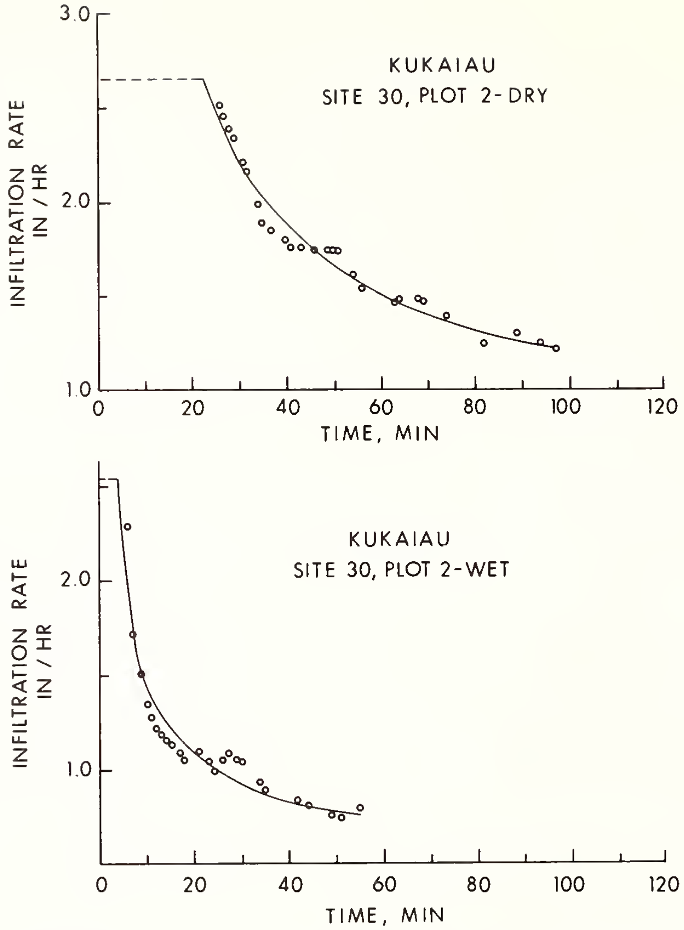


Figure 10.--Measured (circles) and predicted (curve) infiltration during dry and wet runs on a Kukaiau soil.

estimates is clearly illustrated. This distinction becomes even more important in view of changes in agricultural patterns, such as from nonirrigated to irrigated or from surface to drip-irrigation, with soil susceptibilities to erosion being dependent on the moisture regime prevailing under each practice.

2. Soil erodibility factors from simulated construction sites, which were filled, graded, and supported no vegetation, were considerably higher than those from comparable bare agricultural sites on the same soil series (Molokai-A).

3. Higher *K* factors were generally obtained on long rather than on short plots, which indicates overland flow may represent a more erosive factor on Hawaii soils compared with temperate soils of the mainland. This further implies that adjustments using the factors based on "Corn Belt" data are not applicable to Hawaii soils. Further investigation of the topographic factor under Hawaii conditions is needed. Similarly, it is questionable whether adjustments based on *C* factors from USDA Handbook 282 (*46*) are entirely applicable to sugarcane, pineapple, pasture, and other crops in Hawaii. Again, further studies on *C* factors are in order.

4. For agricultural sites on Oahu, *K* factors during dry runs increased in the sequence of Ultisol, Inceptisol, Oxisol, and Vertisol. According to an arbitrary descriptive scale adopted herein (see table 4), erodibility classes within this soil-order sequence ranged from very low to moderate. The same pattern of erodibilities prevailed during wet runs with the exception of Waipahu

soil (Inceptisol), which had the highest *K* factor of agricultural soils studied on Oahu. Under the high soil moisture regime of wet runs, erodibilities ranged from very low to moderately high for the above orders.

On the island of Hawaii, only two soil orders (Inceptisols and Aridisols) were studied. *K* factors under both moisture conditions increased in the sequence of Hilo, Kukaiau, Naalehu, Kawaihae, and Pakini soil series. For the Inceptisols in that sequence, the erodibility increased in the order of Typic Hydrandepts, Hydric Dystrandepts, Typic Eutrandepts, and Entic Eutrandepts subgroups. According to the proposed descriptive classes, erodibilities for these soils ranged from very low to very high. In other words, extremely diverse behavior exists even within the soils from a common origin (volcanic ash).

5. Soil erodibility factors, in general, vary inversely with the natural rainfall (*42*). This relationship is illustrated for the soil series tested on the islands of Oahu (fig. 11) and Hawaii (fig. 12).

6. Actively used plantation roads (Wahiawa series) have considerably higher erodibilities than corresponding agricultural sites. This may have important consequences during erosive storms because an average of 9 to 15 percent of the plantation lands in Hawaii is in roads.

7. Table 10 gives what the authors believe are most representative erodibility data as selected from overall tables mentioned in section VI. The basis for these selections and deviations from overall averages were explained in that section. Briefly, because tests were conducted on two different locations of Waikane soil, an upper location with better structure and a lower location with less stable structure, two different *K* values are deemed necessary. Waipahu soil was judged to have only one site representative of the series because of unusual cloddy conditions that prevailed in the other two sites. Lastly, *K* factors for Kawaihae soil presented in table 10 are those based on runs greater than 90 min only.

8. Analysis of hydrologic data by use of Green-Ampt type equations provides acceptable practical guides for predicting runoff initiation time and rates of infiltration that govern the runoff hydrographs.

The runoff initation time in 7 out of 10 soils exhibited a fairly linear relationship with antecedent soil saturation deficit (final minus initial soil-

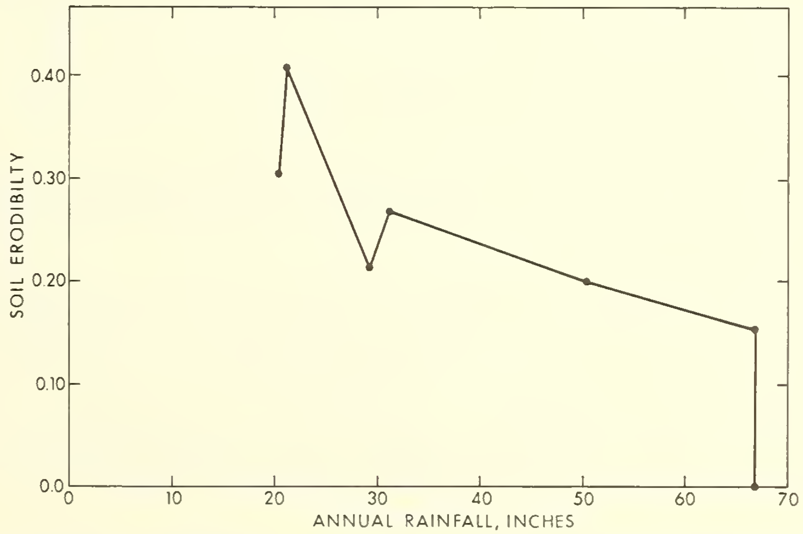


Figure 11.--Erodibility factors as a function of annual rainfall for soil series tested on the island of Oahu.

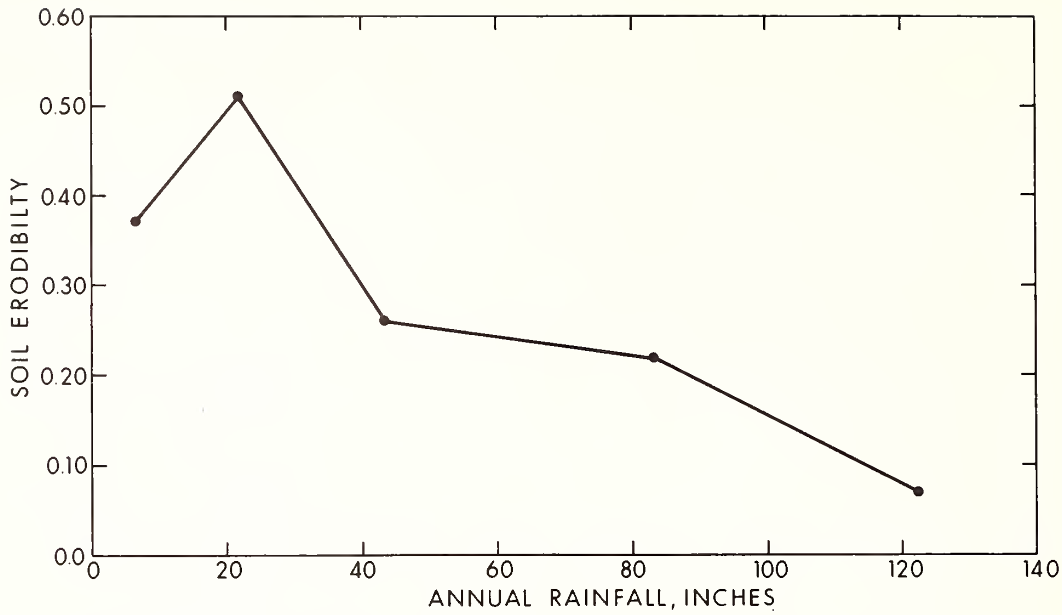


Figure 12.--Erodibility factors as a function of annual rainfall for soil series tested on the island of Hawaii.

water contents). Application of this relationship would result in a more accurate estimate of the erosive portion of a rainstorm and of subsequent soil loss hazards during different seasons of the year.

Analysis of transient infiltration rates showed that infiltration of applied rainfall did not reach the steady state for any of the soils under dry initial conditions. This emphasizes the importance of unsaturated flow properties of soils. A simple two-parameter Green-Ampt type model applied to the data in this case showed a range from good to poor fits. In general, however, the model is reasonably acceptable for field applications. For practical prediction of infiltration rates, average values of the two parameters in the model, one of which depends upon initial soil water status, are given for each soil.

LITERATURE CITED

(1) Adu, S. V.
1972. Eroded savannah soil of the Navrongo-Bawku area, northern Ghana. Ghana Jour. Agr. Sci. 5(1): 3-12.

(2) Ahuja, L. R.
1974. Applicability of Green-Ampt approach to water infiltration through surface crust. Soil Sci. 118: 283-288.

(3) _______ and M. J. M. Romkens.
1974. A similarity during early stages of rain infiltration. Soil Sci. Soc. Amer. Proc. 38: 541-544.

(4) Atkinson, G. D.
1971. Forecasters' guide to tropical meteorology. U.S. Air Force, Air Weather Serv. Tech. Rpt. 240, 360 pp.

(5) Bailey, O. F.
1974. Guidelines for the use of the universal soil loss equation in Hawaii. U.S. Dept. Agr., Soil Conserv. Serv. Tech. Notes, Soils No. 3, 40 pp.

(6) Barnett, A. P., J. R. Carreker, F. Abruna, and A. E. Dooley.
1971. Erodibility of selected tropical soils. Amer. Soc. Agr. Engin. Trans. 14(3): 496-499.

(7) ________ and A. E. Dooley.
1972. Erosion potential of natural and simulated rainfall compared. Amer. Soc. Agr. Engin. Trans. 15(6): 1112-1114.

(8) Bell, T. I. W.
1974. Erosion in the Trinidad teak plantations. (Abstract) Forestry Abs. 35(5): 210[2130].

(9) Blewitt, R. I.
1959. Diversion ditches on sugarcane lands in Hawaii. U.S. Dept. Agr., Soil Conserv. Serv. M-2475, 12 pp.

(10) Cagauan, B., and G. Uehara.
1965. Soil anisotropy and its relation to aggregate stability. Soil Sci. Soc. Amer. Proc. 29: 198-200.

(11) Chibber, R. K., P. C. Ghosh, and K. V. S. Satyanarayana.
1961. Studies on the physical properties of some of the Himachal Pradesh soils formed on different parent materials in relations to their erodibility. Indian Soc. Soil Sci. Jour. 9: 187-192.

(12) Childs, E. C., and M. Bybordi.
1969. The vertical movement of water in stratified porous material: 1. Infiltration. Water Resources Res. 5(2): 446-459.

(13) Christ, J. H.
1960. Aloha Hawaii--some water and soil conservation aspects in the island paradise. Jour. Soil and Water Conserv. 15(1): 11-19.

(14) Dangler, E. W., S. A. El-Swaify, and A. P. Barnett.
1975. Erosion losses from Hawaii soils under simulated rainfall. Hawaii Agr. Expt. Sta. Res. Bul. 181, 77 pp.

(15) El-Swaify, S. A.
1970. The stability of saturated soil aggregates in certain tropical soils as affected by solution composition. Soil Sci. 109: 192-202.

(16) Elwell, H. A., and M. A. Stocking.
1973. Rainfall parameters for soil loss estimation in a subtropical climate. Jour. Agr. Engin. Res. 18: 169-177.

(17) Foote, D. E., E. L. Hill, S. Nakamura, and F. Stevens.
1972. Soil survey of islands of Kauai, Oahu, Maui, Molokai, and Lanai, State of Hawaii. U.S. Dept. Agr., Soil Conserv. Serv., 130 pp.

(18) Foster, G. R., and W. H. Wischmeier.
1974. Evaluating irregular slopes for soil loss prediction. Amer. Soc. Agr. Engin. Trans. 17(2): 305-309.

(19) Green, W. H., and G. A. Ampt.
1911. Studies on soil physics: 1. The flow of air and water through soils. Jour. Agr. Sci. 4: 1-24.

(20) Haridisan, M., and R. K. Chibber.
1971. Effect of physical and chemical properties on the erodibility of some soils on the Malwa Plateau. Jour. Indian Soc. Soil Sci. 19(3): 293-298.

(21) Hillel, D., and W. R. Gardner.
1970. Transient infiltration into crust-topped profiles. Soil Sci. 109: 69-76.

(22) Hudson, N. W.
1961. An introduction to the mechanics of soil erosion under conditions of sub-tropical rainfall. Rhodesia Sci. Assoc. XLIX, Proc. and Trans., part 1: 15-25.

(23) ________
1964. Field measurements of accelerated soil erosion in localized areas. Rhodesia Agr. Jour. 61(3): 47, 48, 60.

(24) ________
1971. Soil conservation. Cornell University Press, Ithaca, N.Y., 320 pp.

(25) Hurault, J.
1972. The erodibility of overgrazed soils in the Adamson High Plateaux (Cameroon). (Abstract) Soils and Fert. 35(2): 170 [1363].

(26) Lopez, J. J., and J. A. Bonnet.
1968. Relative infiltration rate of Puerto Rican Soils. Puerto Rico Univ. Jour. Agr. 52(3): 233-240.

(27) McIntyre, D. S.
1958. Soil splash and the formation of surface crusts by raindrop impact. Soil Sci. 85(5): 261-266.

(28) Manipura, W. B.
1972. Influence of mulch and cover crops on surface runoff and soil erosion on tea lands during the early growth of replanted tea. Tea Quart. 43(3): 95-102.

(29) Mein, R. G., and C. L. Larson.
1973. Modelling infiltration during a steady rain. Water Resources Res. 9: 384-394.

(30) Meyer, L. D.
1960. Use of the rainulator for runoff plots. Soil Sci. Soc. Amer. Proc. 24: 319-322.

(31) ________ and D. L. McCune.
1958. Rainfall simulation for runoff plots. Agr. Engin. 39: 644-648.

(32) Middleton, H. E.
1930. Properties of soil which influence soil erosion. U.S. Dept. Agr. Tech. Bul. 178, 16 pp.

(33) Roose, E. J.
1971. The relative importance of erosion and oblique and vertical drainage in the contemporary pedogenesis of a ferrallitic soil in the mid-Ivory Coast. (Abstract) Soils and Fert. 34(6): 656 [4805].

(34) Rose, C. W.
1960. Soil detachment caused by rainfall. Soil Sci. 89: 28-35.

(35) Sato, H. H., W. Ikeda, R. Paeth, and others.
1973. Soil survey of the island of Hawaii, State of Hawaii. U.S. Dept. Agr., Soil Conserv. Serv., 115 pp.

(36) Sharma, R. R., and N. R. Datta Biswas.
1972. Erodibility of hill soils of Sutles catchment area in Himachal Pradesh. Indian Jour. Agr. Sci. 42(2): 161-169.

(37) Sherman, G. D.
1955. Chemical and physical properties of Hawaiian soils. U.S. Dept. Agr. Soil Survey Ser. 1939(25): 110-124.

(38) ________ Y. Matsusaka, H. Ikawa, and G. Uehara.
1964. The role of the amorphous fraction in the properties of tropical soils. Agrochimica VIII: 146-163.

(39) Soil Conservation Service.
1972. Handbook for erosion and sediment control in urbanizing areas in Hawaii. U.S. Dept. Agr., Soil Conserv. Serv. (Honolulu), 67 pp.

(40) Sundquist, C. T.
1959. Hawaii sugarland conservation experiences. Jour. Soil and Water Conserv. 14(6): 247-250.

(41) Swartzendruber, D.
1974. Infiltration of constant-flux rainfall into soil as analyzed by the approach of Green and Ampt. Soil Sci. 117: 272-281.

(42) Taliaferro, W. J.
1959. Rainfall of the Hawaiian Islands. Hawaii Water Authority, Honolulu, 394 pp.

(43) Van't Woudt, B. D., and G. Uehara.
1961. Erosion behavior and control on a stripmined latosolic soil. Hawaii Agr. Expt. Sta. Tech. Bul. 46, 36 pp.

(44) Williams, M. A. J.
1969. Prediction of rain splash erosion in the seasonally wet tropics. Nature 222: 763-764.

(45) Wischmeier, W. H.
1959. A rainfall erosion index for a universal soil-loss equation. Soil Sci. Soc. Amer. Proc. 23: 246-249.

(46) ________ and D. D. Smith.
1965. Predicting rainfall-erosion losses from cropland east of the Rocky Mountains. U.S. Dept. Agr. Handb. 282, 47 pp.

(47) ________ D. D. Smith, and R. E. Uhland.
1958. Evaluation of factors in the soil-loss equation. Agr. Engin. 39: 458-462, 474.

(48) Wood, H. B.
1971. Land use effects on the hydrologic characteristics of some Hawaii soils. Jour. Soil and Water Conserv. 26(4): 158-160.

(49) Yamamoto, T., and H. W. Anderson.
1967. Erodibility indices for wildland soils of Oahu, Hawaii, as related to soil forming factors. Water Resources Res. 3(3): 785-798.

(50) ________ and H. W. Anderson.
1973. Splash erosion related to soil erodibility indexes and other forest soil properties in Hawaii. Water Resources Res. 9(2): 336-345.

(51) Young, R. A., and R. E. Burwell.
1972. Prediction of runoff and erosion from natural rainfall using a rainfall simulator. Soil Sci. Soc. Amer. Proc. 36: 827-830.

X. APPENDIX

A. Programming Sediment Loss Data

A Fortran computer program for processing sediment loss data was originally obtained from the Southern Piedmont Conservation Center and was modified at the Department of Agronomy and Soil Science, University of Hawaii. Description of the printout headings and program follows:

SITE-YR	= Site number(15), year of test(72): 1572
PLOT	= Dry(1) or Wet(2) run; chemical(1) or nonchemical(0); Plot number 1 or 2: 211
SIZE	= Plot size, ft: 900
INER	= Increment, always 1
MINS	= Effective (corrected) time, minutes: 10
IPH	= Net run-off rate, in/hr: 0.073
INS	= Run-off for time interval, inches: 0.004
AC INS	= Accumulated sum of run-off, inches: 0.925
LBS/MIN	= Soil loss rate, lbs/min: 5.416
LBS/PLT	= Soil loss for time interval (average), lbs: 2.708
AC LBS/PLT	= Accumulated sum of soil loss, lbs: 14.92
AC T/A	= Accumulated sum of soil loss, tons/acre: 3.477
INFINS	= Infiltration for time interval, inches: 0.045
INF/PH	= Infiltration rate, in/hr: 2.700

```
      DIMENSION OBST(100)
      I=0
      IP=0
      SOILF2=0.0
      RATE2P=0.
      SUM11=0.
      SUM17=0.
    1 I=I+1
      READ(5,1000,END=19)ID1,ID2,ISIZE,IINEV,DUR,TOTP,NCARDS,OBST(I),RAT
     *EM,DRYSPQ,VOL
      IF(IP.EQ.0)GO TO 2
      IF(NCARDS.EQ.1)GO TO 20
      GO TO 7
    2 WRITE(6,1001)
      WRITE(8,1001)
      WRITE(10,1001)
      WRITE(7,1001)
      WRITE(9,1001)
      WRITE(11,1001)
      ISITE=ID1/100
      IYEAR=ID1-(100*ISITE)
      IREP=ID2/100
      ICHEM=(ID2-(100*IREP))/10
      IPLOT=(ID2-(100*IREP))-(10*ICHEM)
      WRITE(6,1002)ISITE,IYEAR
      WRITE(8,1002)ISITE,IYEAR
      WRITE(10,1002)ISITE,IYEAR
      WRITE(7,1002)ISITE,IYEAR
      WRITE(9,1002)ISITE,IYEAR
      WRITE(11,1002)ISITE,IYEAR
      IF(ICHEM.EQ.1)GO TO 3
      WRITE(6,1003)
      WRITE(8,1003)
      WRITE(10,1003)
      WRITE(7,1003)
      WRITE(9,1003)
      WRITE(11,1003)
      CHEM=1.0
      GO TO 4
    3 WRITE(6,1004)
      WRITE(8,1004)
      WRITE(10,1004)
      WRITE(7,1004)
      WRITE(9,1004)
      WRITE(11,1004)
      CHEM=1.1429
    4 IF(IREP.EQ.2)GO TO 5
      WRITE(6,1006)
      WRITE(8,1006)
      WRITE(10,1006)
      WRITE(7,1006)
      WRITE(9,1006)
      WRITE(11,1006)
      GO TO 6
    5 WRITE(6,1005)
      WRITE(8,1005)
      WRITE(10,1005)
      WRITE(7,1005)
      WRITE(9,1005)
      WRITE(11,1005)
    6 WRITE(6,1007)
      WRITE(8,1007)
      WRITE(10,1007)
      WRITE(7,1007)
      WRITE(9,1007)
      WRITE(11,1007)
    7 IF(I.NE.1)GO TO 8
      WRITE(6,1008)
      WRITE(8,1008)
```

```
      WRITE(10,1008)
      WRITE(7,2008)
      WRITE(9,2008)
      WRITE(11,2008)
      RATE2P=0.
      SUM11=0.
      SUM17=0.
      SUM19=0.
      IP=2
    8 DRYSPQ=DRYSPQ*CHEM
      JD1=ID1
      JD2=ID2
      JSIZE=ISIZE
      JINEV=IINEV
      DOR=DUR
      TITR=TOTR
      IF(NCARDS.EQ.1)GO TO 9
      OBSTI=OBST(I)-OBST(I-1)
      GO TO 10
    9 OBSTI=0.
   10 IF(RATEM.NE.0.)GO TO 11
      RATE1P=0.
      GO TO 12
   11 RATE1P=((VOL-(DRYSPQ*VOL)/2506.9)/RATEM)*(0.02543/(FLOAT(JSIZE)))
   12 ROTTI=((RATE1P+RATE2P)/2.)*(OBSTI/60.0)
      RATE2P=RATE1P
      IF(RATEM.NE.0.0)GO TO 13
      SOILR1=0.0
      GO TO 14
   13 SOILR1=((DRYSPQ*VOL/946.0)/RATEM)*0.0022
   14 SOILT=((SOILR1+SOILR2)/2.0)*OBSTI
      SOILR2=SOILR1
      IF(NCARDS.EQ.1)GO TO 15
      GO TO 16
   15 ROTTI=0.0
      SOILT=0.0
   16 AINFIL=TOTR/DOR*OBSTI-ROTTI
      BINFIL=TOTR*(60.0/DOR)-RATE1P
      FILTIM=OBST(1)+DOR
      IF(OBST(I).GT.FILTIM)GO TO 17
      GO TO 18
   17 AINFIL=0.0
      BINFIL=0.0
   18 SUM11=SUM11+ROTTI
      SUM17=SUM17+SOILT
      SIZE=JSIZE
      SUM99=SUM17*(21.78/SIZE)
      SUM19=SUM17*(43560.0/(FLOAT(JSIZE))/2000.0)
      WRITE(6,1009)JD1,JD2,JSIZE,JINEV,OBST(I),RATE1P,ROTTI,SUM11,SOILR1
     *,SOILT,SUM17,SUM99,AINFIL,BINFIL
      WRITE(8,1009)JD1,JD2,JSIZE,JINEV,OBST(I),RATE1P,ROTTI,SUM11,SOILR1
     *,SOILT,SUM17,SUM99,AINFIL,BINFIL
      WRITE(10,1009)JD1,JD2,JSIZE,JINEV,OBST(I),RATE1P,ROTTI,SUM11,SOILR
     *1,SOILT,SUM17,SUM99,AINFIL,BINFIL
      WRITE(7,2009)JD1,JD2,JSIZE,OBST(I),BINFIL
      WRITE(9,2009)JD1,JD2,JSIZE,OBST(I),BINFIL
      WRITE(11,2009)JD1,JD2,JSIZE,OBST(I),BINFIL
      GO TO 1
   19 IP=1
   20 WRITE(6,1010)
      WRITE(8,1010)
      WRITE(10,1010)
      WRITE(7,2010)
      WRITE(9,2010)
      WRITE(11,2010)
      WRITE(6,1011)TITR,SUM11,SUM19,DOR
      WRITE(8,1011)TITR,SUM11,SUM19,DOR
      WRITE(10,1011)TITR,SUM11,SUM19,DOR
      WRITE(7,2011)TITR,SUM11,SUM19,DOR
```

```
          WRITE(9,2011)TITR,SUM11,SUM19,DOR
          WRITE(11,2011)TITR,SUM11,SUM19,DOR
          ITOTR=TITR*100.0+0.5
          IDUR=DOR*10.0+0.5
          ISUM11=SUM11*100.0+0.5
          ISUM19=SUM19*100.0+0.5
          OBST(1)=OBST(I)
          I=1
          IF(IP.NE.1)GO TO 2
      100 STOP
     1000 FORMAT(I4,2I3,I1,F4.1,F3.2,I2,F4.1,F4.3,F4.1,F4.0)
     1001 FORMAT(1H1,31('*'))
     1002 FORMAT(1H ,'*****SITE NUMBER',I4,' 19',I2,'******')
     1003 FORMAT(1H ,7('*'),'NON-CHEMICAL RUN',8('*'))
     1004 FORMAT(1H ,9('*'),'CHEMICAL RUN',10('*'))
     1005 FORMAT(1H ,14('*'),'WET',14('*'))
     1006 FORMAT(1H ,14('*'),'DRY',14('*'))
     1007 FORMAT(1H ,31('*'))
     1008 FORMAT(1H0,128H  SITE-YR    PLOT  SIZE  INER    MINS      IPH
         1  INS     AC INS   LBS/MIN   LBS/PLT  AC LBS/PLT  AC T/A     INFIN
         2S    INF/PH/129H+ _______    ____ ____ ____    ____     ___
         3    ___    ______   _______   _______  __________ ______   ___
         4___    ______)
     2008 FORMAT(1H0,51H    SITE-YR     PLOT    SIZE      MINS       INF/PH/
         *52H+    _______    ____   ____    ____     ______)
     1009 FORMAT(4X,I4,6X,I3,3X,I3,3X,I2,2X,F8.1,6(2X,F8.3),2X,F8.4,2(2X,F8.3))
         *3))
     2009 FORMAT(1H ,5X,I4,7X,I3,6X,I3,2X,F8.3,5X,F8.3)
     1010 FORMAT(/////45X,'RAINFALL   TOTAL RO   T SOIL T/A   DURATION'/'+',
         *44X,'________   _______   __________   ________')

     2010 FORMAT(/////'   RAINFALL   TOTAL RO   T SOIL T/A   DURATION'/'+  _
         *_______   ________   __________   ________')
     1011 FORMAT(43X,F8.2,4X,F8.2,4X,F7.2,6X,F6.1)
     2011 FORMAT(1H ,F8.2,4X,F8.2,5X,F7.2,5X,F6.1)
          END
```

B. Tables

Table 1.--*Erosion-runoff data obtained from rainfall simulation experiments*

Site	Plot	Length	Slope	Total rain	Runoff after-- 30 min	60 min	90 min	120 min	Final[1]	Soil loss after-- 30 min	60 min	90 min	120 min	Final[1]	Storm duration[2]
MOLOKAI-A SERIES															
		Feet	*Percent*	*Inches*	*Inches*					*Tons per acre*					*Minutes*
1	1	35	18.4	4.73	0.02	0.33	0.92	1.57	1.59	0.010	1.360	5.270	8.360	8.440	
	2	75	15.8	4.74	.04	.49	1.19	2.01	2.05	.083	4.330	11.03	20.89	21.28	
2	1	35	5.5	5.00	.01	.50	1.26	2.05	2.07	.004	.300	.850	1.440	1.470	
	2	75	6.8	5.03	.03	.56	1.35	2.24	2.32	.029	.990	3.260	5.590	5.780	
3	1	35	14.9	4.62	.02	.37	1.01	1.70	1.73	.024	1.450	5.940	10.63	10.75	
	2	75	15.4	4.83	0	.12	.49	1.04	1.07	0	1.260	6.760	12.41	12.70	
3 wet	1	35	14.9	5.02	.88	1.92	3.00	---	4.09	6.684	13.36	18.64	---	22.89	119.5
	2	75	15.4	4.37	.78	1.84	2.84	---	3.89	10.91	23.60	31.94	---	39.15	119.5
4	1	35	14.5	4.72	0	.04	.20	.53	.73	0	.060	.120	.320	.680	131.0
	2	75	15.2	4.79	.01	.32	1.05	1.82	2.09	.011	4.630	17.32	29.39	32.90	131.0
5	1	35	3.9	5.25	.01	.36	.91	1.65	1.79	.005	.340	.770	1.920	2.230	125.0
	2	75	4.2	5.03	0	.33	.99	1.82	1.99	.002	.480	1.440	2.800	3.140	125.0
6	1	35	5.1	4.81	.01	.23	.76	1.34	1.39	.001	.170	.650	1.170	1.210	
	2	75	4.2	5.19	0	.14	.62	1.23	1.26	.003	.180	1.360	3.080	3.130	
6 wet	1	35	5.1	4.80	.61	1.48	2.35	3.22	3.25	.730	1.940	2.940	3.990	4.020	
	2	75	4.2	5.11	.65	1.56	2.53	3.51	3.58	1.870	4.010	6.960	8.990	9.120	
7	1	35	8.1	4.85	.06	.60	1.33	2.13	2.15	.110	1.620	3.630	4.560	4.570	
	2	75	8.9	4.93	.03	.38	1.01	1.77	1.81	.019	3.050	9.940	16.86	17.06	
7 wet	1	35	8.1	4.69	.86	1.83	2.85	3.84	3.85	2.750	5.800	9.350	11.96	12.02	
	2	75	8.9	4.78	.75	1.70	2.69	3.61	3.64	6.230	12.10	17.15	21.81	22.02	
8	1	35	10.7	4.37	.04	.68	1.60	2.57	2.60	.070	12.46	28.17	40.31	40.75	120.5
	2	75	10.2	4.48	0	.34	.97	1.86	1.91	.002	2.900	15.16	30.59	30.99	120.5
9	2	75	10.2	5.07	.08	.74	1.55	2.47	2.50	.500	9.010	30.56	56.01	57.29	
MOLOKAI-B SERIES															
12	1	35	4.6	3.97	0	.53	1.54	---	3.36	0	.254	.672	---	1.460	103.0
	2	75	4.6	4.36	0	.11	.33	---	.53	0	.220	.840	---	1.380	103.0
12 wet	1	35	4.6	2.01	.76	---	---	---	1.36	.664	---	---	---	1.140	52.0
	2	75	4.6	2.22	.63	---	---	---	1.34	1.833	---	---	---	4.140	52.0
14	1	35	9.0	4.24	.07	.58	1.29	2.07	2.09	.083	2.800	6.570	10.10	10.19	
14 wet	1	35	9.0	5.12	.88	1.97	3.06	4.12	4.21	5.620	11.86	19.36	25.11	25.60	
15	2	75	7.6	5.09	.13	1.01	1.96	2.93	2.95	1.590	12.64	22.56	32.80	32.90	
15 wet	2	75	7.6	5.08	.98	2.04	3.10	4.13	4.15	5.210	11.25	18.32	25.12	25.25	

See footnotes at end of table.

Table 1.--*Erosion-runoff data obtained from rainfall simulation experiments*--Continued

Site	Plot	Length	Slope	Total rain	Runoff after-- 30 min	60 min	90 min	120 min	Final[1]	Soil loss after-- 30 min	60 min	90 min	120 min	Final[1]	Duration[2]
WAIPAHU SERIES															
		Feet	*Percent*	*Inches*	*Inches*					*Tons per acre*					*Minutes*
10	1	35	3.83	5.97	0	0	0	0	0	0	0	0	0	0	
10 wet	1	35	3.83	6.45	0	.08	.15	.22	.37	.001	.090	.186	.306	.420	145.0
11	2	75	5.56	5.15	0	0	.11	.42	.42	0	0	.272	1.284	1.284	
11 wet	2	75	5.56	4.60	.23	.96	1.82	---	2.42	1.456	5.641	11.24	---	15.41	110.0
13	1	35	4.33	4.58	0	0	0	---	0	0	0	0	---	0	112.0
13 wet	1	35	4.33	3.05	.10	.42	---	---	.61	.069	.350	---	---	1.045	77.0
WAHIAWA SERIES															
16	1	35	5.73	3.84	0	.06	.53	1.67	1.67	0	.030	.800	1.640	1.640	
	2	75	6.71	4.62	0	.03	.36	1.17	1.21	0	.010	.690	3.441	3.500	
17	1	35	6.44	4.44	0	.08	.52	---	1.06	0	.060	1.080	---	2.760	118.0
	2	75	7.09	4.83	0	.02	.32	---	.89	0	.010	.910	---	5.750	118.0
17 wet	1	35	6.44	2.62	.18	.92	---	---	.92	.479	4.288	---	---	4.288	65.0
	2	75	7.09	2.57	.02	.76	---	---	.90	.041	4.987	---	---	5.819	65.0
LUALUALEI SERIES															
20	2	75	3.37	5.17	0.03	0.47	1.25	2.16	2.21	0.046	0.468	1.170	2.117	2.170	
20 wet	2	75	3.37	4.88	.75	1.85	3.04	4.00	4.02	.660	1.510	2.220	2.650	2.675	120.5
21	1	35	3.53	5.05	.03	.47	1.16	2.03	2.07	.033	.470	1.410	2.690	2.711	
21 wet	1	35	3.53	5.12	.59	1.55	2.62	3.66	3.75	.844	1.980	3.360	4.390	4.466	
22	2	75	3.04	4.81	.06	.67	1.70	2.54	2.60	.123	1.400	2.800	4.250	4.306	
WAIKANE SERIES															
23	2	75	4.8	7.29	0	0	0	0	0	0	0	0	0	0	180.0
23 wet	2	75	4.8	7.53	0	.01	.02	.04	.13	0	0	.002	.010	.037	180.0
24	2	75	12.2	5.29	0	0	.07	.30	.31	0	0	.484	2.207	2.294	
24 wet	2	75	12.2	5.30	.36	.89	1.54	2.20	2.22	4.020	8.500	14.25	19.42	19.50	
25	1	35	11.9	4.94	0	0	.02	.43	.49	0	0	.012	.884	.991	122.0
25 wet	1	35	11.9	4.94	.09	.80	1.44	2.10	2.11	.279	2.910	5.950	8.918	9.050	
PLANTATION ROADS															
A. *Molokai-B Series*															
18	1	35	3.05	5.17	.78	1.89	3.17	---	3.42	1.875	3.430	4.660	---	4.913	91.5
18 wet	1	35	3.05	5.60	2.39	---	---	---	4.47	4.740	---	---	---	7.540	58.0

B. *WAHIAWA SERIES*

19	1	35	3.90	6.39	.91	2.18	3.46	4.63	4.66	1.348	3.690	5.570	8.028	8.051	
19 wet	1	35	3.90	4.50	.97	2.16	3.37	---	3.82	2.147	4.724	7.137	---	7.174	98.0
							KUKAIAU SERIES								
26	1	35	8.83	5.49	0	.01	.41	1.01	1.03	0	.070	.650	2.202	2.301	
	2	35	9.00	5.43	.01	.22	.78	1.41	1.42	.011	.179	1.970	3.200	3.220	
27	1	35	14.07	5.03	.09	.70	1.54	---	2.16	.636	7.760	16.06	---	21.06	110.0
	2	35	14.67	5.21	.07	.85	1.90	---	2.52	.569	9.740	21.51	---	24.96	110.0
28	1	35	8.80	4.63	.10	.52	1.06	1.67	1.72	.147	1.674	3.432	4.520	4.540	
	2	35	9.47	4.93	.11	.58	1.18	1.75	1.79	.195	1.690	3.740	5.218	5.302	
29	1	35	14.27	2.52	.01	.31	---	---	.56	.023	2.340	---	---	5.117	76.0
	2	35	15.13	3.14	.02	.36	---	---	.62	.053	2.956	---	---	6.143	76.0
30	1	35	15.40	4.19	.08	.57	1.16	---	1.42	1.326	1.530	8.153	---	17.45	100.0
	2	35	15.33	4.41	.02	.46	1.09	---	1.31	.142	4.440	9.460	---	11.47	100.0
30 wet	1	35	15.40	2.31	.48	---	---	---	1.22	4.278	---	---	---	10.26	58.5
	2	35	15.33	2.49	.55	---	---	---	1.34	5.573	---	---	---	14.33	58.5
31	1	35	6.40	2.93	.08	.57	---	---	.80	.122	1.057	---	---	1.535	75.0
	2	35	5.90	3.00	.15	.69	---	---	.86	.267	1.096	---	---	1.406	75.0
32	1	35	5.33	4.58	.17	.79	1.45	2.18	2.29	.563	2.530	4.110	5.152	5.152	
	2	35	5.80	5.38	.35	1.21	2.12	3.33	3.51	1.315	4.668	7.012	11.21	12.31	
33	1	35	4.43	4.89	0	.11	.48	1.01	1.07	0	.114	.417	.842	.887	
	2	35	4.97	4.98	0	.09	.39	.83	.85	0	.088	.387	.901	.933	
33 wet	1	35	4.43	4.01	.62	1.45	2.25	---	2.44	.831	2.472	3.818	---	4.349	98.0
	2	35	4.97	4.23	.60	1.38	2.13	---	2.38	.973	2.007	3.430	---	4.162	98.0
							HILO SERIES								
34	1	35	8.80	4.93	.25	1.28	2.33	3.39	3.49	.562	2.113	3.655	6.085	6.328	
	2	35	9.83	5.52	.47	1.28	2.34	3.44	3.58	.335	1.351	2.692	4.023	4.173	
34 wet	1	35	8.80	4.27	.68	1.71	2.76	---	3.43	.809	1.990	3.317	---	4.203	109.0
	2	35	9.83	5.76	.78	2.13	3.53	---	4.46	1.539	3.722	5.438	---	6.125	109.0
35	1	35	8.30	4.41	.60	1.74	2.98	---	3.63	.891	2.383	3.808	---	4.141	103.0
	2	35	8.40	4.47	.58	.85	3.10	---	3.85	1.139	2.733	4.134	---	4.476	103.0
							KAWAIHAE SERIES								
36	1	35	9.36	4.79	.26	.98	1.79	2.56	2.66	1.433	4.926	8.764	11.59	11.64	
	2	35	8.73	5.07	.07	.55	1.22	2.04	2.06	.463	3.053	6.642	10.57	10.65	
36 wet	1	35	9.36	3.72	.61	1.37	2.21	---	2.33	2.355	4.958	7.551	---	7.914	95.0
	2	35	8.73	3.85	.64	1.44	1.41	---	2.45	3.056	6.371	9.708	---	10.14	95.0
37	1	35	11.20	2.27	.08	---	---	---	.58	.224	---	---	---	3.098	58.0
	2	35	11.50	2.32	.06	---	---	---	.73	.178	---	---	---	4.676	58.0
38	1	35	11.13	5.00	.19	.96	1.84	2.77	2.80	1.466	6.989	13.93	19.78	19.91	
	2	35	11.03	4.82	.38	1.38	2.37	3.48	3.51	2.551	10.97	18.02	26.23	26.47	

See footnotes at end of table.

Table 1.--*Erosion-runoff data obtained from rainfall simulation experiments*--Continued

Site	Plot	Length	Slope	Total rain	Runoff after-- 30 min	60 min	90 min	120 min	Final[1]	Soil loss after-- 30 min	60 min	90 min	120 min	Final[1]	Duration[2]
								KAWAIHAE SERIES--Continued							
		Feet	*Percent*	*Inches*	*Inches*					*Tons per acre*					*Minutes*
38 wet	1	35	11.13	4.52	0.79	1.82	2.77	---	3.62	4.557	10.24	14.61	---	18.22	113.0
	2	35	11.03	4.58	.87	1.86	2.89	---	3.65	4.627	9.631	14.21	---	17.72	113.0
								NAALEHU SERIES							
39	1	35	12.60	4.90	.08	.81	1.77	2.71	2.74	.089	4.689	9.747	14.19	14.29	
	2	35	12.57	4.86	.12	.81	1.71	2.64	2.68	.406	6.325	12.23	17.23	17.45	
40	1	35	8.57	4.89	0	.53	1.41	2.34	2.38	.002	.805	4.234	6.565	6.657	
	2	35	6.60	4.89	.25	1.03	1.90	2.83	2.89	.365	1.245	2.190	3.589	3.711	
40 wet	1	35	8.57	4.94	1.01	1.94	3.01	4.22	4.27	1.628	3.440	5.526	8.089	8.204	
	2	35	6.60	4.89	.99	2.01	3.08	4.11	4.17	2.461	4.983	7.649	10.30	10.45	
								PAKINI SERIES							
41	1	35	5.97	4.17	.19	.81	1.54	---	1.67	1.441	5.607	10.56	---	11.35	95.0
	2	35	6.47	4.27	.21	.86	1.59	---	1.68	1.373	5.485	9.440	---	9.826	95.0
42	1	35	7.13	5.46	.27	.88	1.71	2.43	2.45	2.855	8.322	14.68	18.61	18.70	
	2	35	7.27	5.41	.31	.96	1.67	2.38	2.40	3.745	8.831	13.23	16.62	16.69	
42 wet	1	35	7.13	5.21	.51	1.37	2.38	3.35	3.38	3.252	7.682	12.29	15.99	16.08	
	2	35	7.27	5.28	.52	1.40	2.28	3.20	3.23	2.36	6.428	9.736	11.73	11.77	

[1]Includes runoff and soil loss after storm was stopped.
[2]Unless indicated, storm durations were 120.0 minutes.

Table 2.--*Antecedent and final average soil moisture values*

Site	Plot	θ[1] for depth of 0-3 in		3-6 in		6-12 in		12-18 in		18-24 in	
		MOLOKAI-A SERIES									
		θ_i[2]	θ_f[3]	θ_i	θ_f	θ_i	θ_f	θ_i	θ_f	θ_i	θ_f
1	1	19.8	58.9	23.8	54.1	38.4	54.2	47.4	44.3	42.6	43.7
	2	13.9	54.0	27.4	48.9	32.3	52.0	40.2	50.3	36.7	44.3
2	1	11.3	51.8	15.8	46.5	16.4	36.6	35.3	38.3	34.7	36.6
	2	24.1	52.5	28.3	44.6	33.7	40.8	33.2	38.4	33.1	35.8
3	1	8.0	51.2	14.7	45.4	22.2	43.5	30.4	44.0	36.4	48.7
	2	14.1	51.5	19.4	48.2	23.9	43.9	28.1	46.6	33.3	50.4
3 wet	1	47.5	47.9	45.0	46.1	41.3	46.6	43.0	47.2	44.4	48.7
	2	44.9	51.8	41.2	47.9	42.1	46.2	41.7	44.1	46.1	50.6
4	1	11.7	52.1	19.0	46.7	29.8	45.1	35.3	49.1	37.7	47.2
	2	14.5	51.3	19.5	49.9	29.0	47.2	37.1	42.7	38.6	44.1
5	1	20.4	59.3	19.5	58.2	25.5	56.8	29.7	34.7	31.6	33.2
	2	16.9	57.5	20.3	54.3	22.0	50.6	24.9	35.0	30.5	32.6
6	1	16.1	54.9	17.1	51.0	18.7	44.3	26.4	28.9	30.9	29.7
	2	13.7	52.1	17.2	49.6	19.2	45.9	26.4	33.4	29.7	30.7
6 wet	1	45.5	52.1	43.8	55.9	43.9	51.1	42.1	42.9	38.4	32.3
	2	45.3	54.9	43.2	47.4	42.7	48.6	39.4	48.7	37.6	40.0
7	1	14.1	47.7	15.8	42.4	24.7	37.0	28.2	34.8	28.7	30.3
	2	12.4	50.8	15.5	47.5	22.1	35.3	28.0	33.2	29.9	33.5
7 wet	1	49.2	53.4	45.8	53.5	40.9	48.6	34.8	46.3	31.4	33.4
	2	48.3	53.3	48.2	53.1	42.6	50.6	34.2	37.6	34.2	38.2
8	1	24.3	52.3	31.2	49.1	35.1	41.5	40.8	40.4	43.5	37.4
	2	17.0	49.4	19.8	44.9	24.8	35.5	30.6	31.4	33.5	33.4
9	2	32.0	56.9	34.4	53.7	37.7	48.2	41.0	44.3	40.9	40.7
		MOLOKAI-B SERIES									
12	1	36.5	60.6	38.9	56.0	40.4	52.7	39.7	49.0	33.3	43.6
	2	38.7	59.9	40.6	57.9	41.1	57.4	37.0	49.9	30.6	40.8
12 wet	1	54.5	57.6	51.1	53.1	52.2	---[4]	50.1	---	50.3	---
	2	52.7	59.1	51.5	54.8	49.8	53.2	48.6	51.7	47.8	49.0
14	1	25.6	63.7	30.5	64.6	29.5	50.5	30.6	39.1	31.9	31.6
14 wet	1	61.5	58.5	48.2	59.2	52.0	57.1	45.4	54.8	38.8	41.7
15	2	39.5	53.1	37.4	50.8	38.6	48.6	40.4	44.4	36.7	37.8
15 wet	2	51.2	58.8	49.6	56.9	47.9	55.2	48.1	53.4	47.9	50.0

See footnotes at end of table.

Table 2.--*Antecedent and final average soil moisture values*--Continued

Site	Plot	θ[1] for depth of 0-3 in		3-6 in		6-12 in		12-18 in		18-24 in	
		WAIPAHU SERIES									
		θ_i[2]	θ_f[3]	θ_i	θ_f	θ_i	θ_f	θ_i	θ_f	θ_i	θ_f
10	1	11.3	46.1	14.6	42.0	18.6	47.3	34.8	45.9	34.5	47.2
10 wet	1	40.1	41.9	39.0	40.6	38.4	44.0	38.0	39.2	35.5	43.3
11	2	21.3	39.0	25.1	36.8	25.9	37.2	26.5	36.8	26.0	36.1
11 wet	2	41.9	45.0	39.2	41.2	40.4	41.2	39.0	40.4	36.8	40.6
13	1	22.9	42.2	30.3	45.7	35.3	43.2	35.3	39.7	36.3	39.8
13 wet	1	41.0	44.0	41.2	45.5	43.8	45.0	41.5	40.0	41.0	39.7
		WAHIAWA SERIES									
16	1	28.2	63.4	33.4	64.8	46.3	66.5	47.9	60.3	70.1	60.4
	2	31.0	70.0	34.6	67.4	55.8	67.3	57.3	62.2	52.3	60.7
17	1	49.5	67.7	51.6	64.3	61.5	67.7	56.3	55.3	58.3	60.3
	2	44.7	65.0	50.5	69.4	53.7	61.7	50.5	54.8	51.8	60.5
17 wet	1	55.0	68.2	58.4	66.6	63.2	72.0	59.5	62.8	56.7	65.7
	2	59.8	70.5	62.6	70.3	65.2	61.7	59.7	64.6	54.4	67.6
		LUALUALEI SERIES									
20	2	17.7	80.5	22.0	59.0	23.3	43.1	26.7	36.0	28.0	41.2
20 wet	2	68.3	74.6	56.3	59.9	34.5	47.0	44.8	37.4	33.7	35.2
21	1	18.5	87.4	22.1	56.4	23.9	51.3	26.7	54.3	27.7	46.7
21 wet	1	66.4	69.3	60.9	58.0	58.4	47.5	58.3	47.5	45.6	50.7
22	2	27.9	74.3	29.3	60.7	28.8	48.2	23.6	43.4	30.7	39.2
		WAIKANE SERIES									
23	2	31.7	66.0	40.5	64.9	54.3	69.7	65.8	96.8	76.6	92.5
23 wet	2	54.6	72.6	57.3	71.4	68.0	88.0	84.0	98.3	85.5	101.5
24	2	27.2	53.2	43.5	54.1	47.7	52.0	49.7	51.8	49.5	52.0
24 wet	2	44.6	58.4	50.0	54.5	53.0	55.8	53.5	56.6	52.5	54.8
25	1	33.2	57.0	46.2	60.9	50.2	58.1	51.5	64.2	53.3	56.8
25 wet	1	47.6	55.1	43.3	55.4	52.3	54.1	51.8	49.4	52.2	51.5
		MOLOKAI (ROAD)									
18	1	21.6	40.2	23.6	25.1	24.1	24.3	24.2	---	---	---
18 wet	1	41.5	46.4	32.5	31.1	27.7	27.2	28.5	28.4	---	---

						WAHIAWA (ROAD)					
19	1	29.0	49.5	34.3	56.1	34.3	57.7	38.6	54.1	38.0	37.4
19 wet	1	43.5	45.9	42.5	40.7	41.8	36.5	44.8	38.2	42.8	38.6
						KUKAIAU SERIES					
26	1	27.7	59.5	31.0	52.9	46.1	77.5	64.7	108.0	76.9	97.8
	2	24.0	73.1	34.3	53.4	34.5	53.9	67.6	75.2	98.1	
27	1	45.2	72.3	70.1	77.8	67.2	96.3	54.3	92.6	54.9	98.1
	2	40.1	67.8	55.6	88.3	78.0	111.4	77.6	85.3	74.2	
28	1	50.9	57.9	46.9	55.2	97.2		108.4		111.2	
	2	59.1	67.6	67.5	82.2	95.9	83.1	103.9	100.7	105.7	
29	1	38.7	65.5	47.6	66.8	58.7	58.1	88.3	89.6	106.0	
	2	44.5	96.5	50.4	107.8	76.9	133.3	103.7	146.8	105.3	134.1
30	1	37.5	87.2	52.3	90.5	80.7	110.8	87.3	95.8	79.7	103.9
	2	52.8	92.2	92.7	108.1	109.1	126.8	101.4	109.8	90.5	98.3
30 wet	1	77.6	76.2	72.6	86.6	90.4	112.1	89.5	120.4	90.9	104.5
	2	72.8	93.2	83.3	109.2	98.7	130.3	101.0	132.3	67.1	104.7
31	1	26.5	69.5	37.6	83.0	48.3	98.8	70.6	122.3	78.1	101.1
	2	39.6	72.8	38.8	71.4	62.2	66.3	63.8		57.0	115.3
32	1	58.9	84.9	65.9	138.6	117.8	142.7	135.5	134.5	129.1	143.8
	2	56.9	70.2	57.1	70.8	127.6	124.5	122.2	146.2	142.1	141.5
33	1	47.1	63.5	52.3	61.1	71.5	74.3	103.2	105.2	105.3	
	2	40.2	53.9	49.9	54.6	63.4		101.4		114.3	
33 wet	1	61.6	75.3	63.0	74.1	66.4	93.3	96.8	121.9	110.3	119.8
	2	52.4	69.3	57.9	67.2	62.5	71.8	100.3	101.2	110.9	120.8
						HILO SERIES					
34	1	168.8	204.2	159.0	186.4	184.5	219.3	259.7	292.7	319.1	326.2
	2	119.5	195.6	144.6	182.9	173.9	170.6	223.2	232.7	280.8	317.5
34 wet	1	71.2	106.8	175.1		112.8	142.4	170.5		141.5	
	2	95.2		134.0	171.4	169.5		199.5		191.4	
35	1	178.9		163.5		167.6		236.3		267.4	256.9
	2	125.6	178.8	171.3	194.0	161.2	217.4	241.3		234.2	290.1
						KAWAIHAE SERIES					
36	1	27.5	42.0	27.6	43.6	23.2	48.1	22.5	27.0	21.9	24.3
	2	26.0	42.5	28.3	48.2	28.9	46.4	23.0	40.7	26.5	28.4
36 wet	1	32.9	40.9	36.3	42.7	40.8	50.3	40.2	48.1	36.2	32.6
	2	35.1	40.9	39.8	44.5	44.8	44.5	38.8	43.2	36.1	35.7
38	1	23.2	41.5	24.0	40.5	27.8	43.8	32.8	36.0	35.3	37.2
	2	27.4	41.4	27.2	35.6	25.2	34.9	24.2	27.3	17.4	15.4
38 wet	1	29.4	37.0	31.4	39.6	35.8	42.4	37.4	44.8	36.9	---
	2	31.8	38.5	33.0	35.5	30.4	31.5	31.4	33.6	36.9	32.8

See footnotes at end of table.

Table 2.--*Antecedent and final average soil moisture values*--Continued

Site	Plot	θ^1 for depth of									
		0-3 in		3-6 in		6-12 in		12-18 in		18-24 in	
NAALEHU SERIES											
		θ_i[2]	θ_f[3]	θ_i	θ_f	θ_i	θ_f	θ_i	θ_f	θ_i	θ_f
39	1	56.4	74.2	57.0	69.3	74.2	80.5	84.2	---	89.4	---
	2	53.8	67.3	48.9	64.6	50.7	63.3	---	71.0	---	---
40	1	46.2	79.8	53.4	65.3	65.8	74.0	---	102.7	---	---
	2	57.2	72.8	52.0	72.2	66.4	85.0	92.4	---	---	---
40 wet	1	70.4	70.9	82.0	57.5	82.5	76.2	---	112.8	---	---
	2	66.6	69.3	66.5	65.0	69.1	70.2	---	---	---	---
PAKINI SERIES											
41	1	35.6	75.8	40.9	73.8	43.1	64.4	53.6	53.7	56.9	54.9
	2	40.0	83.8	42.3	74.6	45.5	64.9	44.9	53.7	45.8	48.7
42	1	33.5	80.9	37.6	73.0	36.1	64.1	40.3	46.3	48.3	52.4
	2	36.6	79.6	39.3	71.3	38.6	44.1	45.6	50.1	47.4	52.5
42 wet	1	59.9	81.6	62.3	74.6	55.3	68.8	55.7	75.1	54.1	65.6
	2	58.7	75.9	59.9	65.0	54.8	68.8	62.3	69.6	61.6	69.2

[1]Gravimetric water content, percent.
[2]Antecedent water content.
[3]Final water content.
[4]Dash indicates no sample collected because of interference from rocks.

Table 3.--*Organic residue in test plots*

Site	Plot	Residue, 10^{-2} lb at depth				Total
		0-3 in	3-6 in	6-9 in	9-12 in	(10^{-2} lb/ft^3)
MOLOKAI-A SERIES						
1	1	2.29	2.20	3.31	1.12	8.92
	2	6.67	10.91	5.45	3.90	26.93
2	1	4.74	5.03	1.85	1.76	13.38
	2	5.05	3.24	3.37	1.74	13.40
3	1	1.34	.90	2.23	1.32	5.79
	2	5.42	9.96	2.95	2.23	20.56
4	1	16.18	3.04	7.58	.64	27.44
	2	16.31	2.69	5.11	2.07	26.18

5	1	17.57	11.97	1.43	5.34	36.31
	2	9.39	4.94	4.03	4.45	22.81
6	1	4.06	4.96	9.88	2.20	21.10
	2	3.92	6.19	4.58	5.07	19.76
7	1	9.63	2.98	4.78	2.49	19.88
	2	6.59	5.78	3.33	4.23	19.93
8	1	2.05	1.57	.84	.88	5.34
	2	5.36	5.25	3.86	4.06	18.53
			MOLOKAI-B SERIES			
12	1	4.03	.53	.75	1.87	7.18
	2	2.51	.64	.88	.64	4.67
14	2	1.70	1.65	.44	.26	4.05
15	2	1.12	3.20	1.15	1.04	6.51
			WAIPAHU SERIES			
10	1	.71	1.76	1.59	2.34	6.40
11	2	3.06	.26	2.36	.68	6.36
			WAHIAWA SERIES			
16	1	3.64	2.56	3.28	1.21	10.69
	2	4.34	6.53	4.70	.75	16.32
17	1	2.49	2.09	.93	.26	5.77
	2	2.38	1.85	1.63	.95	6.81
			LUALUALEI SERIES			
20	2	18.61	8.22	4.72	3.73	35.28
21	1	13.10	5.27	6.99	1.90	27.56
22	2	11.40	8.77	4.08	2.31	26.56
			WAIKANE SERIES			
23	1	1.83	2.12	.97	1.10	6.02
			KUKAIAU SERIES			
26	1	8.22	6.26	3.00	.57	18.05
	2	7.76	1.28	.46	1.37	10.87
27	1	12.32	14.55	7.28	5.09	39.24
	2	13.36	7.54	4.23	2.71	27.84
28	1	7.89	8.53	7.98	7.74	32.14
	2	7.67	7.03	4.43	4.61	23.74
29	1	5.47	4.12	3.02	3.31	15.92
	2	6.22	4.94	4.94	3.11	19.21
30	1	8.99	8.09	7.32	3.62	28.02

Table 3.--*Organic residue in test plots*--Continued

Site	Plot	Residue, 10^{-2} lb at depth				Total
		0-3 in	3-6 in	6-9 in	9-12 in	(10^{-2} lb/ft^3)
			KUKAIAU SERIES--Continued			
30	2	5.34	7.96	6.61	3.26	23.17
31	1	3.55	4.94	2.09	1.08	11.66
	2	3.64	3.17	3.04	1.92	11.77
32	1	2.93	2.76	1.56	1.10	8.35
	2	6.50	4.08	.84	5.20	16.62
33	1	9.39	6.75	4.28	1.19	21.61
	2	7.89	3.64	1.39	.99	13.91
			HILO SERIES			
34	1	2.82	6.50	.95	3.00	13.27
	2	6.86	3.62	1.72	1.50	13.70
35	1	6.13	3.75	1.01	1.54	12.43
	2	9.88	1.79	2.98	1.04	15.69
			KAWAIHAE SERIES			
36	1	3.17	12.12	16.01	4.17	35.47
	2	11.79	7.03	5.95	1.41	26.18
38	1	6.26	4.32	12.57	5.00	28.15
	2	4.76	5.64	4.30	5.20	19.90
			NAALEHU SERIES			
39	1	7.25	2.80	2.51	1.81	14.37
	2	3.70	6.79	3.28	4.61	18.38
40	1	7.52	1.81	3.84	1.32	14.49
	2	8.91	3.24	2.67	.82	15.64
			PAKINI SERIES			
41	1	17.46	28.99	10.96	14.00	71.41
	2	28.31	41.95	16.71	11.68	98.65
42	1	19.71	19.25	8.40	8.18	55.54
	2	42.06	10.36	4.83	7.61	64.86

Table 4.--*Numerical and descriptive classes of* K *factors*[1]

Numerical class	Range of *K* values	Descriptive class	Numerical class	Range of *K* values	Descriptive class
1	<0.100	Very low.	8	0.320 - 0.369	Moderately high.
2	0.100 - 0.149	Low.	9	.370 - .429	Do.
3	.150 - .169	Do.	10	.430 - .489	High.
4	.170 - .199	Do.	11	.490 - .549	Do.
5	.200 - .239	Moderate.	12	.550 - .640	Very high.
6	.240 - .279	Do.			
7	.280 - .319	Do.			

[1]Adapted and modified from USDA, Soil Conservation Service, inservice memorandum, Advisory Soils - 6, February 6, 1973. The numerical classes above and their ranges of *K* values are the same as in the memorandum although the format differs. "Descriptive class" has been added for qualitative reference.

Table 5.--*Full storm* K *factors for dry and wet runs on soil test sites*

Site	Plot	Length	Slope average	Total rain	Soil loss (*A*)	*EI* factor[1]	*LS* factor[2]	*C* factor[3]	*K* factor[4]
MOLOKAI-A SOIL TEST SITES (DRY RUNS)[5]									
		Feet	*Percent*	*Inches*	*Tons per acre*				
1	1	35	18.4	4.73	8.440	89.49	2.12	0.75	0.060
1	2	75	15.8	4.74	21.28	89.87	2.62	.75	.120
2	1	35	5.53	5.00	1.470	100.0	.37	.75	.053
2	2	75	6.80	5.03	5.780	101.2	.56	.75	.133
3	1	35	14.9	4.62	10.75	85.38	1.52	.75	.111
3	2	75	15.4	4.83	12.70	93.31	2.35	.75	.077
4	1	35	14.5	5.15	.680	97.18	1.45	.75	.007
4	2	75	15.2	5.23	32.90	100.2	2.30	.75	.191
5	1	35	3.90	5.25	2.230	114.9	.25	.75	.104
5	2	75	4.20	5.03	3.140	105.4	.39	.75	.101
6	1	35	5.10	4.81	1.210	92.54	.32	.75	.055
6	2	75	4.20	5.19	3.130	107.7	.39	.75	.099
7	1	35	8.10	4.85	4.570	94.09	.58	.75	.112
7	2	75	8.90	4.93	17.06	97.22	1.03	.75	.227
8	1	35	10.7	4.37	40.75	76.07	.96	.75	.744
8	2	75	10.2	4.48	30.99	79.95	1.30	.75	.397
9	2	75	10.2	5.07	57.29	102.8	1.30	.75	.572

See footnotes at end of table.

Table 5.—*Full storm K factors for dry and wet runs on soil test sites*—Continued

Site	Plot	Length	Slope average	Total rain	Soil loss (*A*)	*EI* factor[1]	*LS* factor[2]	*C* factor[3]	*K* factor[4]
				MOLOKAI-A SOIL TEST SITES (WET RUNS)[6]					
		Feet	*Percent*	*Inches*	*Tons per acre*				
3 wet	1	35	14.9	5.02	22.89	101.2	1.52	0.75	0.199
3 wet	2	75	15.4	4.77	39.15	91.39	2.35	.75	.243
6 wet	1	35	5.10	4.80	4.020	92.16	.32	.75	.181
6 wet	2	75	4.20	5.11	9.120	104.5	.39	.75	.299
7 wet	1	35	8.10	4.69	12.02	87.98	.58	.75	.315
7 wet	2	75	8.90	4.78	22.02	91.39	1.03	.75	.312
				MOLOKAI-B SOIL TEST SITES (DRY RUNS)[7]					
12	1	35	4.57	3.97	1.460	73.45	.29	.85	.081
12	2	75	4.60	4.36	1.380	88.59	.41	.85	.045
14	1	35	9.05	4.24	10.19	71.91	.77	.85	.216
15	2	75	7.57	5.09	32.90	103.6	.87	.85	.429
				MOLOKAI-B SOIL TEST SITES (WET RUNS)[8]					
12 wet	1	35	4.57	2.01	1.140	37.29	.29	.85	.124
12 wet	2	75	4.60	2.22	4.140	45.49	.41	.85	.261
14 wet	1	35	9.05	5.12	25.60	104.8	.77	.85	.373
15 wet	2	75	7.57	5.08	25.25	103.2	.87	.85	.331
				WAIPAHU SOIL TEST SITES (DRY RUNS)[9]					
10	1	35	3.83	5.97	0	142.6	.22	.75	0
11	2	75	5.56	5.15	1.280	106.1	.54	.75	.029
13	1	35	4.33	4.58	0	89.90	.28	.75	0
				WAIPAHU SOIL TEST SITES (WET RUNS)[10]					
10 wet	1	35	3.83	6.45	.420	137.7	.22	.75	.019
11 wet	2	75	5.56	4.60	15.41	92.33	.54	.75	.412
13 wet	1	35	4.33	3.05	1.040	57.99	.28	.75	.085
				WAHIAWA SOIL TEST SITES (DRY RUNS)[11]					
16	1	35	5.73	3.84	1.640	58.98	.39	.85	.084
16	2	75	6.71	4.62	3.500	85.38	.66	.85	.073
17	1	35	6.44	4.44	2.760	80.19	.46	.85	.088
17	2	75	7.09	4.83	5.750	94.90	.74	.85	.096

				WAHIAWA SOIL TEST SITES (WET RUNS)[12]					
17 wet	1	35	6.44	2.62	4.290	50.69	.46	.85	.216
17 wet	2	75	7.09	2.57	5.820	48.77	.74	.85	.189
				LUALUALEI SOIL TEST SITES (DRY RUNS)[13]					
20	2	75	3.37	5.17	2.170	106.9	.27	.48	.156
21	1	35	3.53	5.05	2.710	102.0	.22	.48	.252
22	2	75	3.04	4.31	4.810	92.54	.27	.48	.358
				LUALUALEI SOIL TEST SITES (WET RUNS)[14]					
20 wet	2	75	3.37	4.88	2.670	94.86	.27	.48	.217
21 wet	1	35	3.53	5.12	4.470	104.9	.22	.48	.404
				WAIKANE SOIL TEST SITES (DRY RUNS)[15]					
23	2	75	4.80	7.29	0	141.7	.45	.80	0
24	2	75	12.2	5.29	2.290	111.9	1.37	.80	.019
25	1	35	11.9	4.94	.990	96.01	1.04	.80	.013
				WAIKANE SOIL TEST SITES (WET RUNS)[16]					
23 wet	2	75	4.80	7.53	.040	151.2	.45	.80	.001
24 wet	2	75	12.2	5.30	19.50	112.4	1.37	.80	.159
25 wet	1	35	11.9	4.94	9.050	97.61	1.04	.80	.111
				PLANTATION ROADS TEST SITES (DRY RUNS)					
				A. Molokai-B Series					
18	1	35	3.05	5.17	4.913	140.2	.18	.925	.210
				B. Wahiawa Series					
19	1	35	3.90	6.39	8.051	163.3	.23	.925	.232
				PLANTATION ROADS TEST SITES (WET RUNS)					
				A. Molokai-B Series					
18	1	35	3.05	5.60	7.540	259.5	.18	.925	.175
				B. Wahiawa Series					
19	1	35	3.90	4.50	7.714	99.18	.23	.925	.366

See footnotes at end of table.

Table 5.--*Full storm K factors for dry and wet runs on soil test sites*--Continued

Site	Plot	Length	Slope average	Total rain	Soil loss (*A*)	*EI* factor[1]	*LS* factor[2]	*C* factor[3]	*K* factor[4]
				KUKAIAU SOIL TEST SITES (DRY RUNS)[17]					
		Feet	*Percent*	*Inches*	*Tons per acre*				
26	1	35	8.83	5.49	2.300	120.6	0.67	0.75	0.037
26	2	35	9.00	5.43	3.220	117.9	.67	.75	.055
27	1	35	14.1	5.03	21.06	110.4	1.44	.75	.176
27	2	35	14.7	5.21	24.96	118.5	1.56	.75	.180
28	1	35	8.80	4.63	4.540	87.75	.72	.75	.099
28	2	35	9.47	4.93	5.300	97.22	.77	.75	.095
29	1	35	14.3	2.52	5.120	40.11	1.39	.75	.123
29	2	35	15.1	3.14	6.140	62.27	1.55	.75	.085
30	1	35	15.4	4.19	17.45	84.27	1.64	.75	.168
30	2	35	15.3	4.41	11.47	93.35	1.68	.75	.097
31	1	35	6.40	2.93	1.540	54.94	.42	.75	.089
31	2	35	5.90	3.00	1.410	57.60	.39	.75	.084
32	1	35	5.33	4.58	5.150	83.91	.34	.75	.241
32	2	35	5.80	5.38	12.13	115.8	.37	.75	.377
33	1	35	4.43	4.89	.890	95.65	.29	.75	.043
33	2	35	4.97	4.98	.930	99.20	.32	.75	.039
				KUKAIAU SOIL TEST SITES (WET RUNS)[18]					
30 wet	1	35	15.4	2.31	10.26	43.78	1.64	.75	.191
30 wet	2	35	15.3	2.49	14.33	50.87	1.68	.75	.224
33 wet	1	35	4.43	4.01	4.350	78.76	.29	.75	.253
33 wet	2	35	4.97	4.23	4.160	87.64	.32	.75	.197
				HILO SOIL TEST SITES (DRY RUNS)[19]					
34	1	35	8.80	4.93	6.330	97.22	.74	.85	.104
34	2	35	9.83	5.52	4.170	121.9	.83	.85	.048
35	1	35	8.30	4.41	4.140	90.63	.60	.85	.089
35	2	35	8.40	4.47	4.480	93.11	.60	.85	.094
				HILO SOIL TEST SITES (WET RUNS)[20]					
34 wet	1	35	8.80	4.27	4.200	80.29	.74	.85	.084
34 wet	2	35	9.83	5.76	6.120	146.1	.83	.85	.059

				KAWAIHAE SOIL TEST SITES (DRY RUNS)[21]					
36	1	35	9.36	4.79	11.64	91.78	.69	.60	.307
36	2	35	8.73	5.07	10.65	102.8	.64	.60	.270
37	1	35	11.2	2.27	3.100	42.64	.95	.60	.128
37	2	35	11.5	2.32	4.680	44.54	1.00	.60	.175
38	1	35	11.1	5.00	19.91	100.0	.93	.60	.357
38	2	35	11.0	4.82	26.47	92.93	.91	.60	.522
				KAWAIHAE SOIL TEST SITES (WET RUNS)[22]					
36 wet	1	35	9.36	3.72	7.910	69.92	.69	.60	.273
36 wet	2	35	8.73	3.85	10.14	74.89	.64	.60	.353
38 wet	1	35	11.1	4.52	18.22	86.78	.93	.60	.377
38 wet	2	35	11.0	4.58	17.72	89.10	.91	.60	.365
				NAALEHU SOIL TEST SITES (DRY RUNS)[23]					
39	1	35	12.6	4.90	14.29	96.04	1.16	.75	.172
39	2	35	12.6	4.86	17.45	94.48	1.20	.75	.205
40	1	35	8.57	4.89	6.660	95.65	.65	.75	.143
40	2	35	6.60	4.89	3.710	95.65	.43	.75	.120
				NAALEHU SOIL TEST SITES (WET RUNS)[24]					
40 wet	1	35	8.57	4.94	8.200	97.61	.65	.75	.172
40 wet	2	35	6.60	4.89	10.45	95.65	.43	.75	.339
				PAKINI SOIL TEST SITES (DRY RUNS)[25]					
41	1	35	5.97	4.17	11.35	87.86	.39	.48	.690
41	2	35	6.47	4.27	9.830	92.12	.44	.48	.506
42	1	35	7.13	5.46	18.70	119.3	.52	.48	.629
42	2	35	7.27	5.41	16.69	117.1	.51	.48	.583
				PAKINI SOIL TEST SITES (WET RUNS)[26]					
42 wet	1	35	7.13	5.21	16.08	108.6	.52	.48	.593
42 wet	2	35	7.27	5.28	11.77	111.5	.51	.48	.431

[1]Refer to equation 1 in text.
[2]Refer to equation 2 in text.
[3]Values modified from USDA Agriculture Handbook No. 282.
[4]$K = A/(EI)(LS)CP$; P assigned value of 1.
[5]K average (dry) for sites 1–9 = 0.186, for agricultural sites 1–6 = 0.093, and for construction sites 7, 8, 9 = 0.410.
[6]K average (wet) for sites 3, 6, 7 = 0.258, for agricultural sites 3, 6 = 0.231, and for construction site 7 = 0.313.
[7]K average (dry) = 0.193.
[8]K average (wet) = 0.272.
[9]K average (dry) = 0.010.

Table 5.--*Full storm* K *factors for dry and wet runs on soil test sites*--Continued

[10] K average (wet) = 0.172.
[11] K average (dry) = 0.085.
[12] K average (wet) = 0.203.
[13] K average (dry) = 0.225.
[14] K average (wet) = 0.311.
[15] K average (dry) = 0.011.
[16] K average (wet) = 0.090.
[17] K average (dry) = 0.124.
[18] K average (wet) = 0.216.
[19] K average (dry) = 0.084.
[20] K average (wet) = 0.072.
[21] K average (dry) = 0.293.
[22] K average (wet) = 0.342.
[23] K average (dry) = 0.160.
[24] K average (wet) = 0.256.
[25] K average (dry) = 0.602.
[26] K average (wet) = 0.512.

Table 6.--*Incremental changes in* K *factor for soils within experimental storms*[1 2]

		K factor			
Site	Plot	30 min	60 min	90 min	120 min
		MOLOKAI-A SOIL			
1	1	0	0.038	0.110	0.087
	2	.002	.079	.152	.223
2	1	.001	.004	.079	.085
	2	.003	.090	.214	.219
3	1	.001	.059	.184	.193
	2	0	.031	.134	.137
3 wet	1	.231	.231	.182	---
	2	.272	.316	.208	---
4	1	0	.002	.002	.008
	2	0	.117	.321	.305
5	1	.001	.064	.085	.222
	2	0	.065	.130	.184
6	1	0	.031	.086	.094
	2	0	.023	.150	.218
6 wet	1	.132	.219	.181	.190
	2	.245	.280	.386	.266
7	1	.011	.148	.196	.091
	2	.001	.161	.367	.368
7 wet	1	.287	.319	.371	.273
	2	.353	.333	.286	.264
8	1	.005	.908	1.152	.890
	2	0	.149	.632	.795
9	2	.020	.340	.860	1.016
		MOLOKAI-B SOIL			
12	1	.013	.029	.085	---
	2	0	.024	.069	---

12 wet	1	.125	---	---	---
	2	.200	---	---	---
14	1	.007	.231	.320	.300
14 wet	1	.328	.364	.437	.335
15	2	.083	.577	.518	.535
15 wet	2	.273	.317	.371	.356
			WAIPAHU SOIL		
10	1	0	0	0	0
10 wet	1	0	.019	.020	.026
11	2	0	0	.025	.094
11 wet	2	.143	.410	.548	---
13	1	0	0	0	---
13 wet	1	.015	.059	---	---
			WAHIAWA SOIL		
16	1	0	.006	.157	.172
	2	0	.001	.057	.230
17	1	0	.008	.128	---
	2	0	.001	.059	---
17 wet	1	.052	.416	---	---
	2	.003	.349	---	---
			LUALUALEI SOIL		
20	2	.013	.122	.188	.274
20 wet	2	.216	.278	.232	.141
21	1	.012	.162	.349	.476
21 wet	1	.305	.410	.498	.372
22	2	.041	.426	.467	.483
			WAIKANE SOIL		
23	2	0	0	0	0
23 wet	2	0	0	0	.001
24	2	0	0	.016	.056
24 wet	2	.131	.145	.187	.168
25	1	0	0	.001	.044
25 wet	1	.014	.132	.152	.149
			PLANTATION ROADS		
			A. Molokai-B Series		
18	1	.245	.203	.161	---
18 wet	1	.212	---	---	---

See footnotes at end of table.

Table 6.--*Incremental changes in K factor for soils within experimental storms*[1] [2]--Continued

Site	Plot	*K* factor			
		30 min	60 min	90 min	120 min
		PLANTATION ROADS--Continued			
		B. Wahiawa Series			
19	1	0.155	0.270	0.216	0.283
19 wet	1	.332	.339	.374	---
		KUKAIAU SOIL			
26	1	0	.005	.038	.102
	2	.001	.011	.121	.083
27	1	.020	.219	.255	---
	2	.015	.242	.311	---
28	1	.012	.126	.152	.098
	2	.014	.106	.146	.105
29	1	.001	.140	---	---
	2	.002	.102	---	---
30	1	.043	.007	.213	---
	2	.004	.122	.142	---
30 wet	1	.155	---	---	---
	2	.169	---	---	---
31	1	.018	.131	---	---
	2	.040	.123	---	---
32	1	.105	.368	.295	.195
	2	.164	.418	.292	.523
33	1	0	.022	.058	.082
	2	0	.015	.050	.086
33 wet	1	.159	.313	.257	---
	2	.151	.161	.221	---
		HILO SOIL			
34	1	.037	.101	.101	.159
	2	.016	.047	.062	.062
34 wet	1	.058	.085	.096	---
	2	.054	.077	.060	---
35	1	.066	.111	.106	---
	2	.082	.115	.101	---

			KAWAIHAE SOIL		
36	1	.151	.368	.404	.297
	2	.047	.262	.364	.398
36 wet	1	.257	.284	.283	---
	2	.336	.365	.367	---
37	1	.018	---	---	---
	2	.013	---	---	---
38	1	.105	.396	.498	.419
	2	.201	.664	.556	.647
38 wet	1	.355	.443	.341	---
	2	.359	.388	.355	---
			NAALEHU SOIL		
39	1	.004	.220	.242	.213
	2	.019	.278	.278	.235
40	1	0	.069	.294	.200
	2	.047	.114	.123	.181
40 wet	1	.137	.152	.175	.215
	2	.319	.327	.346	.344
			PAKINI SOIL		
41	1	.277	.801	.952	---
	2	.223	.669	.643	---
42	1	.383	.734	.853	.528
	2	.522	.709	.614	.473
42 wet	1	.480	.653	.680	.546
	2	.346	.595	.484	.292

[1] See text for explanation of time increments.
[2] Dashes indicate that experiment ended before 30-minute period indicated in column lead.

Table 7.--*Bulk density of surface layer at various sites and plots of the different soil series*

Soil series	Site No.	Plot No.	Bulk density	Soil series	Site No.	Plot No.	Bulk density
			G/cm^3				*G/cm*^{3}
Molokai-A	1	1	1.10	Waikane	24	2	0.88
		2	1.10		25	1	.86
	2	1	1.20	Kukaiau	26	1	.78
		2	1.23			2	.78
	3	1	1.16		27	1	.73
		2	1.04			2	.70
	4	1	1.16		28	1	.72
		2	1.04			2	.70
	5	1	.85		29	1	.69
		2	.97			2	.65
	6	1	1.18		30	1	.70
		2	1.16			2	.63
	7	1	1.26		31	1	.74
		2	1.25			2	.77
	8	1	1.25		32	1	.74
		2	1.26			2	.71
	9	2	1.26		33	1	.57
Molokai-B	12	1	1.03			2	.58
		2	1.19	Hilo	34	1	.47
	14	1	1.10			2	.42
	15	2	1.11		35	1	.50
Molokai-Road	18	1	1.14			2	.55
Waipahu	10	1	1.39	Kawaihae	36	1	.94
	11	2	1.35			2	.88
	13	1	1.35		38	1	1.20
Wahiawa	16	1	.94			2	1.12
		2	.97	Naalehu	39	1	.76
	17	1	.98			2	.76
		2	1.01		40	1	.73
Wahiawa-Road	19	1	1.17			2	.70
Lualualei	20	2	1.22	Pakini	41	1	.66
	21	1	1.22			2	.62
	22	2	1.08		42	1	.70
Waikane	23	2	.93			2	.65

Table 8.--*Infiltration characteristics of different soils and sites in rain simulation studies*

Soil	Site	Plot	Final infiltration rate (in/hr)	Steady state achieved (S) or not (NS)	Constants of fitted equation 6		Nature of fit	Comments on the run
					A	*B*		
				ISLAND OF OAHU				
Molokai-A	1[1]	1	0.934	NS	1.49	0.051	Poor	
		2	.70	NS	- .193	2.46	Good	
	2	1	.83	NS	- .273	3.01	Good	
		2	.70	NS	- .225	2.61	Good	
	3	1	.81	NS	.0949	2.17	Good	
		2	1.18	NS	.762	2.26	Fair	
	3 wet	1	.37	S	.11	.143	Fair	
		2	.315	S	- .131	.245	Fair	
	4	1	1.37	NS	1.47	1.28	Poor	Machine breakdowns.
		2	.79	NS	.242	2.03	Poor	Do.
	5	1	1.01	NS	.505	2.52	Fair	Do.
		2	.76	NS	- .289	3.63	Fair	Do.
	6	1	1.14	NS	.374	2.59	Good	
		2	1.28	NS	.856	2.31	Poor	
	6 wet	1	.65	S	.429	.219	Good	
		2	.58	S	.258	.362	Good	
	7	1	.80	NS	- .0593	2.13	Good	
		2	.881	NS	.427	1.93	Fair	
	7 wet	1	.34	S	.085	.110	Fair	Pressure fluctuations.
		2	.46	S	.138	.214	Poor	Do.
	8	1	.27	NS	-1.19	3.63	Good	Construction site.
		2	.34	NS	- .699	3.32	Poor	Construction site, runoff water blocked.
	9	2	.60	NS	- .0109	1.90	Good	
Waipahu	11	2	1.77	NS	.938	4.40	Fair	Cloddy, graded site.
	11 wet	2	.584	NS	.0199	1.31	Good	Do.
	13 wet	1	1.60	S	1.49	.393	Poor	
Molokai-B	12	1	.358	NS	-2.90	6.54	Fair	
		2	2.01	NS	1.73	1.07	Good	
	12 wet	1	.465	NS	.293	.0781	Fair	
		2	.881	S	.387	.310	Fair	
	14	1	.494	NS	- .261	1.67	Good	
	14 wet	1	.395	S	.297	.069	Poor	
	15	2	.472	NS	- .097	1.46	Fair	Machine breakdown.
	15 wet	2	.40	S	.281	.043	Fair	
	18	1	.91	NS	1.00	.273	Poor	Road site.
Wahiawa	16	1	.625	NS	- .324	2.94	Poor	

See footnote at end of table.

Table 8.--*Infiltration characteristics of different soils and sites in rain simulation studies*--Continued

Soil	Site	Plot	Final infiltration rate (in/hr)	Steady state achieved (S) or not (NS)	Constants of fitted equation 6		Nature of fit	Comments on the run
					A	*B*		
				ISLAND OF OAHU--Continued				
Wahiawa		2	0.60	NS	-0.40	4.62	Poor	
	17	1	.90	NS	- .692	5.12	Good	Machine breakdown.
		2	.973	NS	- .745	7.21	Poor	Do.
	17 wet	1	.663	NS	.141	1.17	Fair	Do.
			.40	NS	.304	1.16	Poor	Do.
	19	1	.67	NS	.553	.187	Poor	Road site.
	19 wet	1	.26	NS	.0847	.131	Fair	Do.
Lualualei	20	2	.667	NS	- .0554	2.66	Fair	
	20 wet	2	.092	S	-1.54	.911	Fair	
	21	1	.61	NS	.0815	2.39	Poor	Machine breakdown.
	21 wet	1	.26	NS	- .227	.68	Fair	Do.
	22	2	.40	NS	- .440	2.14	Good	
Waikane	23 wet	2	2.38	NS	2.40	.229	Poor	
	24	2	1.99	NS	1.43	3.43	Fair	
	24 wet	2	1.28	NS	1.36	.187	Fair	
	25	1	1.45	NS	-1.99	1.45	Fair	
	25 wet	1	1.14	S	.543	1.18	Poor	
				ISLAND OF HAWAII				
Kukaiau	26	1	.66	NS	.609	4.13	Poor	
		2	1.39	NS	.771	2.59	Fair	
	27	1	.955	NS	.186	2.16	Fair	Machine breakdown.
		2	.685	NS	- .875	3.69	Good	Do.
	28	1	.97	NS	.841	.838	Fair	
		2	1.14	NS	.81	1.04	Good	
	29	1	.98	NS	- .0227	1.87	Poor	Do.
		2	1.28	NS	.729	1.72	Fair	Do.
	30	1	.97	NS	.767	1.15	Poor	Do.
		2	1.22	NS	.474	2.28	Good	Do.
	30 wet	1	.660	NS	.238	.440	Fair	
		2	.772	NS	.391	.386	Good	
	31	1	.92	NS	.246	1.53	Fair	
		2	1.10	NS	.552	1.03	Good	
	32	1	.744	NS	.379	.909	Good	Do.
		2	.46	NS	.00273	1.21	Good	Do.
	33	1	1.27	NS	.58	3.00	Fair	
		2	1.45	NS	.933	2.59	Fair	
	33 wet	1	.8	S	.627	.164	Fair	
		2	1.02	S	.829	.175	Poor	

Table 8.--*Infiltration characteristics of different soils and sites in rain simulation studies*--Continued

Soil	Site	Plot	Final infiltration rate (in/hr)	Steady state achieved (S) or not (NS)	Constants of fitted equation 6		Nature of fit	Comments on the run
					A	*B*		
				ISLAND OF HAWAII				
Hilo	34	1	.206	NS	-1.02	1.73	Fair	
		2	.50	NS	- .36	1.55	Fair	
	34 wet	1	.26	S	- .132	.254	Fair	
		2	.462	S	-1.24	1.66	Fair	
	35	1	.045	NS	- .986	.954	Fair	Machine breakdown.
		2	.157	NS	-2.43	2.04	Good	Do.
Kawaihae	36	1	.567	NS	.157	.942	Good	
		2	.682	NS	.390	1.72	Fair	
	36 wet	1	.666	NS	.653	.099	Fair	Machine breakdown. pressure fluctuations.
		2	.574	NS	.657	.105	Fair	Do.
	37	1	.994	NS	-2.08	1.87	Fair	Machine breakdown, aborted run.
		2	1.17	NS	1.46	.05	Poor	Do.
	38	1	.531	NS	- .185	1.54	Good	
		2	.067	N	- .99	1.41	Fair	
	38 wet	1	.293	NS	.101	.164	Fair	
		2	.397	S	.246	.08	Fair	
Naalehu	39	1	.341	NS	- .829	2.67	Good	
		2	.454	NS	- .390	1.94	Good	
	40	1	.490	NS	-1.46	4.62	Fair	
		2	.497	NS	- .127	1.27	Good	
	40 wet	1	.265	S	.226	.0285	Fair	Pressure fluctuations.
		2	.30	S	.27	.019	Fair	Do.
Pakini	41	1	1.08	NS	.732	.992	Good	Machine breakdown.
		2	1.01	NS	1.39	.072	Poor	Do.
	42	1	1.17	NS	.892	.790	Fair	Pressure fluctuation.
		2	1.21	NS	1.03	.571	Fair	Do.
	42 wet	1	.610	S	.258	.546	Fair	
		2	.82	S	.426	.496	Fair	

[1]Absence of the label "wet" by the site number indicates a dry run.

Table 9.--*Average values of the infiltration parameters A and B for different soil series*

Soil	A			B		
	Dry run	Wet run	All runs	Dry run	Wet run	All runs
Molokai-A	-0.0064	0.1502	0.0396	2.5700	0.2158	1.8776
Waipahu	.9380	.0199	.4790	4.4000	1.3100	2.8550
Molokai-B	-0.3820	.2403	- .0810	2.6850	.1437	1.5959
Wahiawa	- .6920	.1129	- .1554	5.1200	.6565	2.1403
Lualualei	- .2480	- .8835	- .5656	2.4000	.7955	1.5978
Waikane	- .280	1.360	.3600	2.4400	.1870	.8757
Kukaiau	.4329	.4193	.4304	1.8910	.3300	1.5986
Hilo	-1.1990	- .686	-1.0280	1.5690	2.1000	1.7457
Kawaihae	- .1670	.071	- .0612	1.4960	.1120	.8811
Naalehu	- .7020	.248	- .3850	2.6250	.0240	1.7579
Pakini	.8850	.342	.6676	.7840	.5210	.6790

Table 10.--*Summary of K factors and erodibility classes*

Soil series	Classification	*K*, dry	Erodibility class	*K*, wet	Erodibility class
		ISLAND OF OAHU			
Waikane silty clay (Upper)	Humoxic Tropohumults	0	Very low	0	Very low.
Waikane silty clay (Lower)	--do--	.02	--do--	.14	Low.
Waipahu silty clay	Vertic Ustropepts	.03	--do--	.41	Moderately high.
Wahiawa silty clay	Tropeptic Eutrustox	.09	--do--	.20	Moderate.
Molokai silty clay loam-A	Typic Torrox	.09	--do--	.23	Do.
Molokai silty clay loam-B	--do--	.19	Low	.27	Do.
Molokai-B (road)	--do--	.21	Moderate	.18	Low.
Wahiawa (road)	Tropeptic Eutrustox	.23	--do--	.37	Moderately high.
Lualualei clay	Typic Chromusterts	.26	--do--	.31	Moderate.
Molokai-A (simulated construction)	Typic Torrox	.41	Moderately high	.31	Do.
		ISLAND OF HAWAII			
Hilo silty clay loam	Typic Hydrandepts	.08	Very low	.07	Very low.
Kukaiau silty clay loam	Hydric Dystrandepts	.12	Low	.22	Moderate.
Naalehu extremely stony silty clay loam, thin solum variant	Typic Eutrandepts	.16	--do--	.26	Do.
Kawaihae very rocky, very fine sandy loam	Ustollic Camborthids	.36	Moderately high	.34	Moderately high.
Pakini very fine sandy loam	Entic Eutrandepts	.60	Very high	.51	High.

Table 11.--*Time elapsed from start of rainfall application on various soils until runoff commenced*

Series	Site	Plot	Minutes elapsed
OAHU SOILS			
Molokai-A	1	1	27
		2	23
	2	1	23
		2	19
	3	1	22
		2	27
	3 wet	1	2
		2	3
	4	1	26
		2	17
	5	1	23
		2	27
	6	1	27
		2	24
	6 wet	1	3
		2	3
	7	1	22
		2	18
	7 wet	1	2
		2	2
	8	1	26
		2	28
	9		13
Dry run average			22.9
Wet run average			2.5
Molokai-B	12	1	32
		2	33
	12 wet	1	3
		2	3
	14	1	19
	14 wet	1	3
	15	1	9
	15 wet	2	2
Dry run average			23.3
Wet run average			2.8

See footnote at end of table.

Series	Site	Plot	Minutes elapsed
OAHU SOILS			
Molokai (road)	18	1	1
	18 wet	1	1
Wahiawa (road)	19	1	4
	19 wet	1	4
Waipahu	10	1	([1])
	10 wet	1	18
	11	2	60
	11 wet	2	13
	13	1	([1])
	13 wet	1	12
Dry run average			60.0
Wet run average			14.3
Wahiawa	16	1	36
		2	36
	17	1	48
		2	48
	17 wet	1	10
		2	10
Dry run average			42.0
Wet run average			10.0
Lualualei	20	2	19
	20 wet	2	4.5
	21	1	21
	21 wet	1	5.5
	22	2	15
Dry run average			18.0
Wet run average			5.0
Waikane	23	2	([1])
	23 wet	2	48
	24	2	60
	24 wet	2	2
	25	1	82
	25 wet	1	12
Dry run average			71.0
Wet run average			20.7

Table 11.--*Time elapsed from start of rainfall application on various soils until runoff commenced*--Continued

Series	Site	Plot	Minutes elapsed
	ISLAND OF HAWAII		
Kukaiau	26	1	37
		2	25
	27	1	17
		2	19
	28	1	10
		2	12
	29	1	26
		2	20
	30	1	22
		2	24
	30 wet	1	5
		2	4
	31	1	17
		2	12
	32	1	10
		2	10
	33	1	39
		2	38
	33 wet	1	4
		2	3
Dry run average			21.2
Wet run average			4.0
Hilo	34	1	18
		2	19
	34 wet	1	7
		2	7
	35	1	10
		2	8
Dry run average			13.8
Wet run average			7.0

Series	Site	Plot	Minutes elapsed
	ISLAND OF HAWAII		
Kawaihae	36	1	9
		2	16
	36 wet	1	2
		2	2
	37	1	18
		2	18
	38	1	12
		2	10
	38 wet	1	2
		2	1
Dry run average			11.8
Wet run average			1.8
Naalehu	39	1	20
		2	15
	40	1	29
		2	10
	40 wet	1	1
		2	1
Dry run average			18.5
Wet run average			1.0
Pakini	41	1	10
		2	11
	42	1	10
		2	9
	42 wet	1	8
		2	7
Dry run average			10.0
Wet run average			7.5

[1]No runoff.

Table 12.--*Miscellaneous test run information* [*Dashes indicate no available data*]

Site	Date	Starting time	Air temperature	H_2O temperature	Weather statement
			MOLOKAI-A SERIES		
			°F	°F	
1	7/17/72	1530	86	79	
2	7/20/72	1000	74	78	Cloudy, windy.
3	7/24/72	1200			Scattered clouds; cool, windy.
3 wet	7/25/72	1200	80	78	Cloudy, cool; wind 15-20 m/h.
4	7/27/72	1130	80	78	Cloudy; N.E. winds (across plot, left to right), 15-20 m/h.
5	8/ 1/72				Humid, hot; no wind.
6	8/ 4/72	1200	74	81	
6 wet	8/ 5/72	1000	85	80	Cloudless day; light breeze.
7	8/ 8/72	1230	90	82	Cloudless; windy.
7 wet	8/ 9/72	---	---	---	
8	8/11/72	---	---	---	
9	8/15/72	1630	83	79	Sunny; N.E. winds (upslope), 15-20 m/h.
			MOLOKAI-B SERIES		
12	11/13/72		79	74	Overcast; N.E. winds (across plot, right to left), 10-20 m/h.
12 wet	11/14/72	1300	79	74	N.E. winds, 10-20 m/h.
14	12/26/72	1100	80	73	Bright sun; N.E. winds, 15-20 m/h (gusts 25 m/h, 2 hour).
14 wet	12/27/72	1100	80	70	Sunny, scattered clouds; N.E. winds, 10 m/h.
15	1/ 9/73	1200	86	74	Bright sun; light N.E. winds.
15 wet	1/10/73	1100	82	72	Bright sun; N.E. winds, 5 m/h.
			WAIPAHU SERIES		
10	8/31/72	1400	93	75	Overcast, high humidity; S. winds, 5-8 m/h.
10 wet	9/ 1/72				
11	9/20/72	1300	93	75	
13	11/20/72	1300	87	75	Bright sun; N.E. winds (downslope), 10 m/h (gusts 15 m/h).
13 wet	11/21/72	1100	80	73	Cloudy; N.E. winds, 5-10 m/h.
			WAHIAWA SERIES		
16	2/22/73	1300	72	67	Overcast; N.W. winds, 10-20 m/h (gusts 25 m/h).
17	3/12/73	1430	83	70	Sunny; N.E. winds, 10-15 m/h (gusts 20 m/h).
17 wet	3/13/73		80	70	Sunny; N.E. winds, 15-20 m/h.

Table 12.--*Miscellaneous test run information* [*Dashes indicate no available data*]--Continued

Site	Date	Starting time	Air temperature	H_2O temperature	Weather statement
				LUALUALEI SERIES	
			°F	°F	
20	6/ 6/73	1300	85	75	Overcast to partly cloudy; N.E. winds (upslope), 15-20 m/h.
20 wet	6/ 7/73	1330	85	75	Overcast to partly cloudy; N.E. winds (upslope), 15-20 m/h.
21	5/14/73	1330	90	75	Sunny to partly cloudy; N.E. winds (upslope), 15-25 m/h, (gusts 30 m/h).
21 wet	6/15/73	1300	93	76	Sunny to partly cloudy; N.E. winds (upslope), 15-20 m/h.
22	7/ 7/73	1330	88	77	Sunny; N.E. winds (upslope), 10-15 m/h.
				WAIKANE SERIES	
23	7/24/73	1430	86	73	Sunny; N.E. winds (upslope), 5-10 m/h.
23 wet	7/25/73		82	72	Light showers.
24	2/27/74	1330	85	71	Overcast; high humidity.
24 wet	2/28/74	1330	82	73	Sunny to overcast; humid.
25	3/ 4/74	1430	84	71	N.E. winds, 10-15 m/h.
25 wet	3/ 5/74	1430	76	71	Overcast; light rain before run; N.E. winds, 5-10 m/h.
				PLANTATION ROADS	
				Molokai-B Series	
18	4/26/73	1430	70	85	Overcast with frequent showers.
18 wet	4/27/73	1200	82	75	Sunny; N.E. winds, 15-25 m/h (gusts 30 m/h).
				Wahiawa Series	
19	5/ 7/73		82	86	Sunny; moderate N.E. winds.
19 wet	5/ 8/73		83	77	Sunny; N.E. winds, 15-20 m/h.
				KUKAIAU SERIES	
26	9/ 5/73	1430	79	78	Sunny, low humidity; N.E. winds, 10-15 m/h.
27	9/10/73		78	76	Sunny, moderate humidity; N.E. winds, 10 m/h.
28	9/17/73	1000	82	72	Sunny, moderate humidity; N.E. winds, 15 m/h (gusts 25 m/h).

29	9/22/73	0930	82	73	Sunny, low humidity; N.E. winds, 15-20 m/h (gusts 25 m/h).
30	9/26/73	1000	82	73	Overcast (45 min), sunny; N.E. winds, 15 m/h.
30 wet	9/27/73	0930	86	70	Sunny; N.E. winds, 15 m/h.
31	10/24/73	1130	81	72	Partly cloudy to overcast; N.E. winds, 10 m/h (gusts 15 m/h).
32	10/24/73	1030	79	72	Sunny; N.E. winds, 15-20 m/h.
33	10/31/73	1400	79	74	Sunny; N.E. winds, 10-15 m/h.
33 wet	11/ 1/73	1030	81	72	Sunny; N.E. winds, 5-15 m/h.
				HILO SERIES	
34	11/ 7/73	1300			Overcast, humid; S. winds, 5-10 m/h.
34 wet	11/ 8/73	1200	87	71	Bright (whitish volcanic haze); S. winds, 5 m/h.
35	11/16/73	1330	78	72	Overcast to sunny; high humidity; N.E. winds, 5 m/h.
				KAWAIHAE SERIES	
36	12/ 4/73	1300	81	77	Sunny; S.W. winds, 5 m/h.
36 wet	12/ 5/73	1100	88	77	Sunny; S.W. winds, 5 m/h.
37	12/13/73	1300			Sunny; N.W. winds, 10 m/h.
38	12/17/73	1200	86	78	Sunny; N.W. winds, 0-5 m/h.
38 wet	12/18/73	1000	79	79	Sunny.
				NAALEHU SERIES	
39	1/15/74	1100	81	70	Slight volcanic hzze; N.E. winds, 0-5 m/h.
40	1/23/74	1400	73	68	Overcast (45 minutes); moderate humidity; variable winds (N.W. to S.W.).
40 wet	1/24/74	1100	69	66	N.W. winds, 10 m/h (gusts 15 m/h).
				PAKINI SERIES	
41	1/30/74	1230	86	76	Sunny; N.E. winds, 5-10 m/h.
42	2/13/74	0600	68	70	Dark, clear; N.E. winds, 10 m/h.
42 wet	2/14/74	0545	71	70	Dark, clear; N.E. winds, 10-15 m/h.

Table 13.--*Infiltration rate as a function of time in different runs*

MOLOKAI-A SOIL

SITE 1 PLOT 1-DRY		SITE 1 PLOT 2-DRY		SITE 2 PLOT 1-DRY		SITE 2 PLOT 2-DRY	
TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR
27.0	2.31	23.0	2.29	23.0	2.50	19.0	2.51
28.0	2.30	24.0	2.28	24.0	2.46	20.0	2.48
30.0	2.27	26.0	2.23	26.0	2.45	22.0	2.47
32.0	2.24	27.0	2.18	27.0	2.43	23.5	2.44
33.0	2.22	28.0	2.15	28.0	2.41	24.0	2.43
34.0	2.17	30.0	2.06	29.0	2.35	25.5	2.37
35.0	2.11	32.0	2.01	30.0	2.31	26.0	2.25
36.0	2.08	33.0	1.81	31.0	2.23	26.5	2.26
37.0	2.03	36.0	1.70	32.0	2.19	28.0	2.20
38.0	1.97	38.0	1.69	33.0	2.15	29.0	2.14
39.0	2.06	39.0	1.65	35.0	2.00	30.0	2.05
40.0	2.02	42.0	1.49	36.0	1.87	32.0	1.86
43.0	1.91	43.0	1.42	37.0	1.65	32.5	1.84
46.0	1.58	45.0	1.38	40.0	1.65	35.0	1.67
48.0	1.56	48.0	1.32	42.0	1.36	36.0	1.59
49.0	1.53	50.0	1.27	45.0	1.39	38.0	1.42
52.0	1.40	53.0	1.18	48.0	1.29	41.0	1.40
57.0	1.43	54.5	1.13	49.0	1.27	42.0	1.39
66.0	1.09	58.0	1.15	56.0	1.21	44.0	1.36
67.0	1.12	63.0	1.12	60.0	1.21	49.0	1.34
72.0	1.22	65.5	1.10	63.0	1.15	50.0	1.34
73.0	1.24	68.0	1.05	68.0	1.01	55.5	1.37
77.0	1.06	70.5	1.00	73.0	0.91	59.0	1.26
87.0	1.33	73.0	0.95	83.0	0.95	60.0	1.24
97.0	0.97	75.5	0.88	91.0	0.80	64.0	0.94
107.0	0.97	81.0	0.94	101.0	0.98	66.0	0.94
117.0	0.89	83.0	0.92	111.0	0.83	69.0	0.94
		87.0	0.89	116.0	1.14	76.5	0.94
		92.5	0.81	119.0	0.82	79.0	0.97
		93.0	0.82			79.5	0.98
		94.0	0.83			84.5	0.82
		95.5	0.86			85.5	0.89
		98.5	0.63			87.0	0.87
		99.5	0.65			91.5	0.80
		103.0	0.67			97.0	0.76
		104.5	0.68			99.0	0.74
		105.5	0.64			105.0	0.78
		110.5	0.84			107.0	0.75
		111.5	0.68			110.5	0.70
		114.0	0.64			116.0	0.65
		115.5	0.74			117.0	0.67
		119.0	0.93			119.0	0.70

Table 13.--*Infiltration rate as a function of time in different runs*--Continued

MOLOKAI-A SOIL--Continued

SITE 3 PLOT 1-DRY		SITE 3 PLOT 2-DRY		SITE 3 PLOT 1-WET		SITE 3 PLOT 2-WET	
TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR
22.0	2.31	27.0	2.41	2.0	2.52	2.5	2.39
23.0	2.25	28.0	2.40	3.0	2.00	3.5	1.86
25.0	2.21	30.0	2.39	4.0	1.15	4.0	1.81
27.0	2.16	32.0	2.39	5.0	1.03	5.5	1.48
29.0	2.10	34.0	2.38	6.0	0.86	6.0	1.23
30.0	2.04	36.0	2.35	7.0	0.14	7.0	0.98
31.0	2.02	37.0	2.31	8.0	0.77	7.5	0.87
32.0	1.99	39.0	2.25	9.0	0.78	8.0	0.71
35.0	1.93	40.0	2.23	10.0	0.77	9.0	0.73
38.0	1.85	41.0	2.22	11.0	0.66	9.5	0.73
41.0	1.68	43.0	2.21	12.0	0.50	11.5	0.68
44.0	1.60	44.0	2.20	14.0	0.61	12.0	0.67
47.0	1.48	46.0	2.19	15.0	0.58	12.5	0.64
52.0	1.35	49.0	2.13	16.0	0.54	14.0	0.56
60.0	1.30	51.0	2.10	18.0	0.47	15.5	0.51
62.0	1.28	52.0	2.08	21.0	0.41	17.0	0.50
65.0	1.25	57.0	1.94	24.0	0.38	17.8	0.35
67.0	1.17	58.0	1.90	25.0	0.36	18.5	0.40
70.0	1.06	64.0	1.86	27.0	0.24	21.0	0.51
72.0	1.02	67.0	1.79	30.0	0.51	21.5	0.49
80.0	0.88	69.0	1.73	35.0	0.32	26.5	0.39
82.0	0.90	72.0	1.69	40.0	0.36	27.5	0.39
90.0	0.96	75.0	1.65	45.0	0.57	31.0	0.38
92.0	0.96	77.0	1.64	51.0	0.63	32.5	0.33
100.0	0.95	78.5	1.64	52.0	0.38	34.5	0.24
102.0	0.94	85.0	1.55	59.0	0.36	37.5	0.38
105.0	0.90	87.0	1.50	61.0	0.38	38.0	0.41
107.0	0.88	90.5	1.41	62.0	0.38	42.5	0.27
110.0	0.86	96.0	1.30	67.0	0.39	45.5	0.20
112.0	0.82	97.0	1.35	70.5	0.26	46.0	0.20
115.0	0.79	100.5	1.44	75.5	0.49	51.0	0.33
117.0	0.77	105.0	1.28	80.5	0.39	56.0	0.25
119.0	0.74	106.0	1.20	85.5	0.26	56.5	0.24
		107.0	1.22	90.5	0.45	60.5	0.30
		112.0	1.25	95.5	0.40	65.5	0.38
		117.0	1.16	100.5	0.46	66.5	0.39
		118.5	1.15	105.5	0.20	72.5	0.48
				110.5	0.39	81.0	0.37
				115.5	0.35	86.0	0.23
				118.5	0.35	92.0	0.25
						101.0	0.29
						105.0	0.34
						106.0	0.36
						112.0	0.36
						115.0	0.36
						118.0	0.38

Table 13.--*Infiltration rate as a function of time in different runs*--Continued

MOLOKAI-A SOIL--Continued

SITE 4 PLOT 1-DRY		SITE 4 PLOT 2-DRY		SITE 5 PLOT 1-DRY		SITE 5 PLOT 2-DRY	
TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR
26.0	2.36	17.0	2.39	23.0	2.63	27.0	2.51
27.0	2.34	18.0	2.38	24.0	2.57	28.0	2.47
29.0	2.33	20.0	2.38	26.0	2.52	30.0	2.44
30.0	2.33	22.0	2.38	28.0	2.51	32.0	2.41
39.5	2.32	24.0	2.36	30.0	2.49	33.0	2.39
40.5	2.32	24.5	2.36	32.0	2.45	34.0	2.37
41.5	2.32	26.0	2.35	33.0	2.42	36.0	2.28
45.0	2.32	27.0	2.34	36.0	2.27	36.5	2.23
46.0	2.32	29.0	2.29	38.0	2.18	37.0	2.20
47.0	2.32	30.0	2.28	39.0	2.15	39.0	2.04
49.0	2.28	35.5	2.22	42.0	2.02	40.0	1.98
50.0	2.28	36.5	2.23	45.0	1.80	41.0	1.90
51.0	2.27	40.5	2.16	48.0	1.80	43.0	1.81
54.0	2.22	46.0	1.99	53.0	1.62	44.5	1.73
58.0	2.21	49.0	1.92	62.0	1.59	46.0	1.68
62.0	2.09	50.0	1.35	63.0	1.58	49.0	1.52
64.0	2.13	51.0	1.26	67.0	1.54	49.5	1.50
65.0	2.12	52.5	0.97	68.0	1.54	52.0	1.58
72.0	2.07	59.0	1.07	72.0	1.53	54.0	1.64
73.0	2.07	61.0	1.09	73.0	1.53	57.0	1.59
75.0	2.02	64.0	1.14	81.0	1.57	59.0	1.55
76.0	1.98	69.5	1.04	85.0	1.51	65.0	1.47
80.0	1.97	80.0	0.76	90.0	1.28	67.0	1.38
81.0	1.97	81.0	0.78	95.0	1.27	71.5	1.08
84.0	1.95	88.0	0.82	100.0	1.01	72.0	1.08
85.0	1.95	91.0	0.88	105.0	1.02	75.5	1.06
89.0	1.90	94.0	0.95	110.0	1.28	82.0	1.11
93.0	1.84	101.0	0.89	115.0	1.01	83.0	1.12
95.0	1.80	103.0	0.88	120.0	1.18	87.5	0.94
104.0	1.66	105.0	0.87	124.0	1.01	92.0	1.08
105.0	1.66	112.0	0.79			97.0	0.81
109.0	1.63	117.0	0.82			101.0	0.91
114.0	1.59	121.0	0.78			102.0	0.90
119.0	1.57	125.0	0.74			106.0	0.81
123.0	1.55					111.0	0.98
125.0	1.48					112.0	0.97
130.0	1.37					116.0	0.95
						120.5	0.66
						122.0	0.59

Table 13.--*Infiltration rate as a function of time in different runs*--Continued

MOLOKAI-A SOIL--Continued

SITE 6 PLOT 1-DRY		SITE 6 PLOT 2-DRY		SITE 6 PLOT 1-WET		SITE 6 PLOT 2-WET	
TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR
27.0	2.40	24.0	2.59	3.0	2.40	3.0	2.55
28.0	2.39	25.0	2.56	4.0	2.20	4.0	2.41
32.0	2.34	27.0	2.56	5.0	1.34	4.5	2.38
32.3	2.32	27.5	2.56	6.0	1.26	5.5	2.19
34.0	2.31	29.0	2.54	7.0	1.16	6.0	1.99
34.3	2.31	30.0	2.52	8.0	1.67	8.0	1.55
36.0	2.27	31.0	2.52	9.0	1.35	9.0	1.27
37.0	2.26	33.0	2.52	10.0	1.19	10.0	1.18
38.0	2.24	34.0	2.51	11.0	0.97	12.0	0.98
40.0	2.15	35.0	2.49	12.0	0.99	12.5	0.91
43.0	2.02	37.0	2.47	13.0	1.02	13.5	0.91
46.0	1.96	40.0	2.45	15.0	1.04	16.0	0.93
49.0	1.85	41.0	2.44	16.0	1.01	19.0	0.82
52.0	1.62	43.0	2.42	19.0	0.86	20.5	0.76
61.5	1.53	45.5	2.39	21.0	0.86	22.0	0.77
63.5	1.53	46.0	2.38	22.0	0.85	23.5	0.76
65.5	1.49	49.0	2.30	25.0	0.80	25.0	0.73
67.5	1.43	50.5	2.23	28.0	0.59	26.5	0.72
70.5	1.40	54.0	2.06	33.0	0.66	28.0	0.72
72.5	1.39	55.5	1.93	38.0	0.88	31.0	0.75
75.5	1.20	59.5	2.30	43.0	0.68	33.0	0.75
77.5	1.07	62.5	2.17	48.0	0.51	36.0	0.75
82.5	1.23	66.5	1.59	53.0	0.53	41.5	0.83
85.5	1.31	67.5	1.60	58.0	0.78	43.0	0.80
87.5	1.38	69.5	1.63	63.0	0.64	45.0	0.78
94.5	1.24	72.5	1.60	68.0	0.60	48.0	0.72
95.5	1.25	75.5	1.57	73.0	0.68	50.5	0.64
99.5	1.32	80.0	1.58	78.0	0.66	53.0	0.72
104.5	1.22	82.5	1.50	83.0	0.67	54.5	0.76
105.5	1.22	85.5	1.40	88.0	0.58	59.5	0.68
109.5	1.23	92.0	1.30	93.0	0.61	63.0	0.62
114.5	1.11	92.5	1.31	98.0	0.75	65.0	0.57
115.5	1.13	97.0	1.44	103.0	0.64	71.5	0.53
118.5	1.16	101.0	1.41	108.0	0.66	73.0	0.62
		102.5	1.38	113.0	0.58	74.0	0.68
		106.5	1.28	117.0	0.64	76.0	0.68
		111.5	1.37	118.0	0.64	79.5	0.60
		112.5	1.35	119.0	0.64	83.0	0.60
		117.0	1.13			93.0	0.58
						94.0	0.58
						103.0	0.58
						104.5	0.56
						111.5	0.66
						113.0	0.66
						117.0	0.64
						119.0	0.54

Table 13.--*Infiltration rate as a function of time in different runs*--Continued

MOLOKAI-A SOIL--Continued

SITE 7 PLOT 1-DRY		SITE 7 PLOT 2-DRY		SITE 7 PLOT 1-WET		SITE 7 PLOT 2-WET	
TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR
22.5	2.35	18.0	2.40	2.0	2.07	2.0	2.39
23.5	2.34	19.0	2.40	3.0	1.88	3.0	2.14
25.5	2.25	24.5	2.36	4.0	0.86	3.5	2.12
26.5	1.99	26.5	2.34	5.0	0.32	5.0	1.89
27.5	1.92	27.5	2.32	6.0	0.53	6.0	0.94
28.5	1.82	28.5	2.32	7.0	0.52	7.0	0.92
29.5	1.78	30.5	2.31	8.0	0.49	9.0	0.83
30.5	1.72	31.5	2.31	9.0	0.53	11.0	0.74
31.5	1.65	32.5	2.30	10.0	0.57	11.5	0.72
32.5	1.54	34.5	2.25	12.0	0.53	12.0	0.72
34.5	1.63	37.5	1.99	14.0	0.45	15.0	0.58
35.5	1.54	40.5	1.92	15.0	0.29	17.5	0.47
36.5	1.44	42.5	1.86	18.0	0.45	18.0	0.47
38.5	1.54	43.5	1.81	21.0	0.46	21.0	0.48
41.5	1.35	46.5	1.65	24.0	0.32	22.0	0.47
44.5	1.27	47.5	1.57	27.0	0.32	24.0	0.47
47.5	1.21	51.5	1.48	32.0	0.34	26.0	0.49
52.5	1.20	52.5	1.45	37.0	0.31	27.0	0.50
57.5	1.20	57.5	1.44	42.0	0.63	31.0	0.45
62.5	1.09	61.5	1.34	47.0	0.32	32.0	0.44
66.5	1.11	62.5	1.31	52.0	0.29	34.5	0.49
67.5	1.08	66.5	1.25	57.0	0.52	39.5	0.53
71.5	0.97	67.5	1.23	62.0	0.45	42.0	0.52
72.5	0.96	71.5	1.22	67.0	0.30	47.0	0.49
76.5	0.92	72.5	1.22	72.0	0.21	47.5	0.47
81.5	0.80	77.5	1.11	77.0	0.20	52.0	0.40
82.5	0.81	81.5	1.05	82.0	0.29	53.0	0.38
86.5	0.85	82.5	1.04	87.0	0.31	58.0	0.50
91.5	0.89	87.5	1.04	92.0	0.50	62.0	0.51
92.5	0.88	91.5	1.05	97.0	0.19	63.0	0.52
96.5	0.86	92.5	1.06	102.0	0.47	67.5	0.43
101.5	0.78	97.5	0.84	107.0	0.49	72.0	0.39
102.5	0.80	101.5	0.90	112.0	0.26	73.0	0.39
106.5	0.86	102.5	0.91	117.0	0.41	78.5	0.43
111.5	0.86	107.5	0.93	119.0	0.44	82.0	0.49
112.5	0.84	111.5	0.91			83.5	0.48
116.5	0.78	112.5	0.90			88.5	0.45
119.5	0.78	117.5	0.94			92.0	0.38
						93.5	0.34
						99.0	0.80
						102.0	0.71
						103.5	0.66
						108.5	0.63
						112.0	0.47
						113.5	0.41
						117.5	0.39
						119.5	0.36

Table 13.--*Infiltration rate as a function of time in different runs*--Continued

MOLOKAI-A SOIL--Continued

SITE 8 PLOT 1-DRY		SITE 8 PLOT 2-DRY		SITE 9 PLOT 2-DRY	
TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR
25.3	2.18	28.3	2.23	13.0	2.53
26.3	2.01	29.3	2.18	14.0	2.52
28.3	1.47	30.3	2.15	16.0	2.51
30.3	1.61	31.3	2.13	18.0	2.48
32.3	1.53	33.3	2.06	19.0	2.40
34.3	1.52	34.3	1.97	20.0	2.38
35.3	1.39	35.3	1.92	22.0	2.31
37.3	0.89	37.3	1.77	23.0	2.25
38.3	0.82	38.3	1.63	24.0	2.17
39.3	0.74	39.3	1.39	26.0	2.03
41.3	0.79	41.3	1.39	27.0	1.92
42.3	0.83	44.3	1.40	29.0	1.85
44.3	0.83	45.3	1.40	30.0	1.81
46.3	0.82	47.3	1.39	32.0	1.72
47.3	0.81	50.3	1.36	34.0	1.62
50.3	0.77	51.3	1.38	35.0	1.59
52.3	0.71	53.3	1.38	40.0	1.45
55.3	0.59	56.3	1.39	41.0	1.44
57.3	0.51	58.3	1.39	43.0	1.16
62.3	0.25	62.3	1.39	44.0	1.05
65.3	0.22	63.3	1.39	49.0	0.94
67.3	0.19	68.3	1.40	50.0	0.94
70.3	0.31	73.3	1.00	54.0	0.98
72.3	0.37	74.3	0.84	59.0	0.92
75.3	0.38	79.3	0.65	60.0	0.93
77.3	0.40	83.3	0.70	64.0	0.99
82.3	0.46	84.3	0.72	69.0	1.32
85.3	0.37	89.3	0.55	70.0	1.19
87.3	0.31	93.3	0.51	74.0	0.67
92.3	0.32	97.3	0.45	78.0	0.78
95.3	0.21	103.3	0.68	80.0	0.77
96.3	0.18	104.3	0.71	83.0	0.74
102.3	0.23	109.3	0.30	89.0	0.88
105.3	0.28	113.3	0.34	90.0	0.86
107.3	0.30	115.8	0.36	94.0	0.82
112.3	0.25	120.3	0.37	99.0	0.71
115.3	0.25			100.0	0.69
119.3	0.26			104.0	0.65
				109.0	0.52
				110.0	0.57
				114.0	0.65
				119.0	0.73

Table 13.--*Infiltration rate as a function of time in different runs*--Continued

WAIPAHU SOIL

SITE 10 PLOT 1-WET		SITE 11 PLOT 2-DRY		SITE 11 PLOT 2-WET		SITE 13 PLOT 1-WET	
TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR
18.0	2.67	60.0	2.57	13.0	2.51	12.0	2.38
19.0	2.65	61.0	2.49	14.0	2.11	13.0	2.11
23.0	2.65	63.0	2.49	15.0	2.08	14.0	2.11
25.0	2.65	64.0	2.49	16.5	2.06	15.0	2.11
113.0	2.43	67.0	2.47	17.0	2.02	16.0	2.12
115.0	2.43	69.0	2.46	19.0	1.92	17.0	2.10
117.0	2.41	70.0	2.45	21.0	1.76	19.0	2.08
120.0	2.38	73.0	2.38	25.0	1.35	21.0	2.05
125.0	2.29	74.0	2.35	30.0	1.14	22.0	2.03
130.0	2.29	76.0	2.33	33.0	1.13	23.0	2.03
135.0	2.18	78.0	2.32	35.5	1.14	25.0	2.01
137.0	2.63	79.0	2.31	36.0	1.11	28.0	1.98
144.0	2.09	82.0	2.26	39.0	1.06	28.5	1.98
		84.0	2.22	40.0	1.04	31.0	1.95
		85.0	2.22	42.0	1.06	34.0	1.91
		89.0	2.19	45.0	1.06	34.5	1.90
		90.0	2.17	47.0	1.08	37.0	1.86
		94.0	2.07	50.0	1.04	40.0	1.81
		99.0	2.01	56.0	0.99	42.0	1.75
		100.0	2.00	60.0	0.97	45.0	1.65
		104.0	1.97	65.0	0.89	52.0	1.57
		105.0	1.96	70.0	0.84	52.5	1.56
		109.0	1.94	75.0	0.78	62.0	1.60
		110.0	1.92	80.0	0.75	69.0	1.60
		114.0	1.86	86.0	0.68	72.0	1.60
		117.0	1.80	90.0	0.67		
		120.0	1.77	93.0	0.65		
				94.0	0.65		
				103.0	0.58		
				106.0	0.58		

Table 13.--*Infiltration rate as a function of time in different runs*--Continued

MOLOKAI-B SOIL

SITE 12 PLOT 1-DRY		SITE 12 PLOT 2-DRY		SITE 12 PLOT 1-WET		SITE 12 PLOT 2-WET	
TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR
32.0	2.31	33.0	2.54	3.0	2.32	3.0	2.56
33.0	2.23	34.0	2.43	4.0	0.82	4.0	2.29
34.0	2.20	36.0	2.43	5.0	0.78	6.0	2.12
35.0	2.08	38.0	2.42	7.0	0.73	8.0	1.10
36.0	2.03	40.0	2.40	9.0	0.69	10.0	1.10
37.0	2.00	49.0	2.29	11.0	0.69	12.0	1.12
38.0	1.97	56.0	2.15	12.0	0.68	13.0	1.08
39.0	1.88	63.0	2.13	13.0	0.64	16.0	1.01
40.0	0.53	66.0	2.13	16.0	0.58	19.0	0.94
41.0	0.68	72.0	2.14	19.0	0.51	22.0	0.87
49.0	1.12	73.0	2.12	20.0	0.50	25.0	0.89
54.0	0.79	76.5	2.05	22.0	0.50	28.0	0.91
55.0	0.79	78.0	2.05	25.0	0.50	33.0	0.89
58.0	0.79	83.0	2.04	28.0	0.50	35.0	0.89
61.0	0.79	91.0	2.04	29.0	0.49	40.0	0.87
64.0	0.78	93.0	2.04	33.0	0.48	43.0	0.87
66.0	0.78	103.0	2.01	34.0	0.48	48.0	0.87
67.0	0.74			39.5	0.46		
70.0	0.64			43.0	0.46		
72.0	0.57						
75.0	0.36						

Table 13.--*Infiltration rate as a function of time in different runs*--Continued

MOLOKAI-B SOIL--Continued

SITE 14 PLOT 1-DRY		SITE 14 PLOT 1-WET		SITE 15 PLOT 2-DRY		SITE 15 PLOT 2-WET	
TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR
19.0	2.12	3.0	2.56	9.0	2.54	1.5	2.54
20.0	1.95	4.0	0.71	10.0	2.46	2.5	1.57
21.0	1.93	5.0	0.71	12.0	2.45	3.0	1.42
22.0	1.90	6.0	0.70	13.0	2.45	4.5	0.68
23.0	1.84	7.0	0.71	14.0	2.44	5.0	0.16
24.0	1.83	8.0	0.71	16.0	2.43	6.5	0.26
26.0	1.79	10.0	0.63	18.0	2.40	7.0	0.32
28.0	1.59	12.0	0.58	19.0	2.38	8.5	0.32
29.0	1.52	13.0	0.56	22.0	2.26	10.0	0.32
32.0	1.38	16.0	0.53	24.0	1.93	10.5	0.29
33.0	1.34	19.0	0.52	25.0	1.84	11.5	0.28
35.0	1.27	22.0	0.52	27.0	1.58	13.0	0.26
36.0	1.23	25.0	0.49	28.0	1.54	14.5	0.30
38.0	1.15	27.0	0.44	31.0	1.31	17.0	0.34
39.0	1.10	28.0	0.43	34.0	1.10	17.5	0.36
41.0	1.05	32.0	0.47	35.0	1.04	20.5	0.44
43.0	0.95	33.0	0.45	39.0	0.94	21.5	0.46
44.0	0.96	37.0	0.36	40.0	0.91	23.5	0.42
46.0	0.96	43.0	0.35	45.0	0.65	24.0	0.42
49.0	1.01	47.0	0.35	49.0	0.62	26.5	0.44
52.0	1.07	48.0	0.36	51.5	0.59	31.5	0.46
59.0	0.89	52.0	0.37	53.0	0.59	36.0	0.48
64.0	0.72	53.0	0.38	56.0	0.57	41.5	0.42
67.0	0.74	57.0	0.41	64.0	0.66	43.0	0.38
69.0	0.74	63.0	0.40	68.0	0.69	46.5	0.32
73.0	0.75	67.0	0.39	69.0	0.70	48.5	0.28
79.0	0.70	73.0	0.36	75.0	0.78	51.5	0.38
81.0	0.67	77.0	0.34	78.0	0.70	53.5	0.44
89.0	0.63	83.0	0.39	83.0	0.55	61.5	0.47
92.0	0.62	87.0	0.42	88.0	0.51	63.5	0.49
99.0	0.58	93.0	0.46	98.0	0.47	71.0	0.37
106.0	0.53	97.0	0.49	108.0	0.57	71.5	0.39
109.0	0.53	103.0	0.47	117.0	0.48	81.5	0.43
114.0	0.53	107.0	0.44			83.0	0.43
119.0	0.50	113.0	0.42			91.5	0.45
120.0	0.49	117.0	0.42			93.0	0.45
						101.5	0.47
						103.0	0.47
						110.0	0.39
						112.0	0.37
						118.0	0.41
						118.5	0.42

Table 13.--*Infiltration rate as a function of time in different runs*--Continued

MOLOKAI-B SOIL--Continued

SITE 18 PLOT 1-DRY		SITE 18 PLOT 1-WET	
TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR
1.0	3.39	1.0	5.79
2.0	2.60	2.0	2.26
4.0	2.59	4.0	1.23
6.0	2.59	6.0	0.84
8.0	2.58	8.0	0.42
8.5	2.57	9.0	0.15
10.0	2.42	10.0	-0.01
11.0	2.32	11.0	-0.18
12.5	1.65	11.5	-0.29
14.0	1.50	14.0	0.16
15.5	1.39	17.0	0.64
17.0	1.40	19.0	0.92
20.0	1.41	20.0	0.91
20.5	1.41	22.0	0.91
23.0	1.23	23.0	0.96
23.5	1.18	26.0	1.05
26.0	1.20	27.0	1.09
26.5	1.20	31.0	0.98
29.5	1.28	32.0	0.96
35.5	1.18	39.0	1.20
36.0	1.17	41.0	1.15
40.5	1.08	45.0	1.09
46.0	1.15	46.0	1.13
48.5	1.19	50.0	1.32
51.0	1.21	51.0	1.32
55.5	1.23	57.0	1.38
56.0	1.19		
62.5	0.87		
66.0	0.80		
71.5	0.74		
76.0	0.82		
81.5	0.93		
86.0	0.93		
90.5	0.93		
91.0	0.93		

Table 13.--*Infiltration rate as a function of time in different runs*--Continued

WAHIAWA SOIL

SITE 16 PLOT 1-DRY		SITE 16 PLOT 2-DRY		SITE 17 PLOT 1-DRY		SITE 17 PLOT 2-DRY	
TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR
36.0	1.92	36.0	2.31	48.0	2.26	48.0	2.46
37.0	1.84	37.0	2.27	49.0	1.98	49.0	2.38
38.0	1.84	39.0	2.27	50.0	1.99	51.0	2.38
41.0	1.83	41.0	2.27	51.0	2.00	53.0	2.39
42.0	1.82	43.0	2.27	52.0	1.96	55.0	2.38
43.0	1.82	45.0	2.26	53.0	1.94	57.0	2.36
45.0	1.79	46.0	2.26	54.0	1.86	58.0	2.36
46.0	1.80	49.0	2.25	55.0	1.83	61.0	2.34
49.0	1.80	52.0	2.24	57.0	1.78	62.0	2.33
52.0	1.78	54.0	2.23	58.0	1.73	64.0	2.32
55.0	1.72	55.0	2.22	61.0	1.67	67.0	2.30
58.0	1.67	58.0	2.19	64.0	1.61	69.0	2.28
60.0	1.37	60.0	2.18	67.0	1.52	70.0	2.25
70.0	1.33	70.0	2.01	70.0	1.42	73.0	2.09
75.0	1.16	75.0	1.66	73.0	1.36	74.0	1.97
80.0	0.38	76.0	1.45	78.0	1.30	78.0	1.65
90.0	0.78	80.0	1.39	88.0	1.20	79.0	1.52
100.0	0.62	82.0	1.37	93.0	0.99	88.0	1.24
110.0	0.61	90.0	0.92	98.0	0.91	93.0	1.14
		96.0	0.71	108.0	0.90	94.0	1.13
		100.0	0.69			98.0	1.07
		103.0	0.67			99.0	1.06
		107.0	0.59			106.0	0.97
		110.0	0.59			109.0	0.98
		115.0	0.59				
		119.0	0.59				

Table 13.--*Infiltration rates as a function of time in different runs*--Continued

WAHIAWA SOIL--Continued

SITE 17 PLOT 1-WET		SITE 17 PLOT 2-WET		SITE 19 PLOT 1-DRY		SITE 19 PLOT 1-WET	
TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR
10.0	2.42	10.0	2.37	4.0	3.19	4.0	2.75
11.0	2.38	11.0	2.35	5.0	1.19	5.0	0.81
12.0	2.36	12.0	2.34	7.0	1.14	6.0	0.76
13.0	2.34	13.0	2.34	9.0	1.10	7.0	0.70
14.0	2.34	14.0	2.34	11.0	1.05	9.0	0.59
15.0	2.34	15.0	2.34	12.0	1.02	9.5	0.55
16.0	2.25	16.0	2.34	13.0	1.02	11.0	0.54
17.0	1.89	17.0	2.33	14.0	1.02	12.5	0.54
19.0	1.85	18.0	2.32	17.0	1.01	13.0	0.50
20.0	1.82	19.0	2.32	18.0	1.00	14.0	0.46
26.0	1.59	20.0	2.32	19.0	1.05	16.0	0.35
29.0	1.48	26.0	2.29	22.0	1.16	17.0	0.36
32.0	1.33	29.0	2.18	24.0	1.24	20.0	0.39
35.0	1.05	30.0	2.01	25.0	1.17	21.0	0.39
40.0	0.95	32.0	1.83	28.0	0.87	23.0	0.42
50.0	0.91	34.0	1.22	29.0	0.74	25.5	0.47
55.0	0.71	35.0	1.14	33.0	0.77	26.0	0.45
60.0	0.66	37.0	1.01	34.0	0.77	29.0	0.34
		40.0	0.85	38.5	0.62	30.0	0.29
		47.0	0.61	43.0	0.63	34.0	0.37
		50.0	0.40	45.5	0.64	36.0	0.43
		54.0	0.43	48.0	0.63	42.0	0.42
		55.0	0.46	52.0	0.62	44.0	0.40
		56.0	0.49	53.0	0.61	48.0	0.38
				57.0	0.59	49.0	0.36
				63.0	0.56	53.0	0.30
				65.0	0.55	54.0	0.30
				73.0	0.67	63.0	0.28
				76.0	0.72	64.0	0.29
				83.0	0.65	72.0	0.40
				88.0	0.59	74.0	0.37
				93.0	0.72	80.5	0.29
				95.0	0.76	84.0	0.26
				103.0	0.81	85.0	0.26
				107.0	0.85	94.0	0.23
				110.0	0.83		
				117.0	0.78		

Table 13.--*Infiltration rate as a function of time in different runs*--Continued

LUALUALEI SOIL

SITE 20 PLOT 2-DRY		SITE 20 PLOT 2-WET		SITE 21 PLOT 1-DRY	
TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR
19.0	2.58	4.5	2.43	19.0	2.52
20.0	2.53	5.5	2.33	20.0	2.42
22.0	2.47	6.5	2.31	22.0	2.40
24.0	2.46	7.5	2.26	24.0	2.39
26.0	2.38	9.5	1.16	25.0	2.38
26.5	2.34	11.5	0.92	26.0	2.33
28.0	2.28	13.0	0.62	27.0	2.23
29.0	2.23	13.5	0.53	28.0	2.21
29.5	2.21	14.5	0.41	29.0	2.20
32.0	2.15	17.5	0.03	30.0	2.18
34.0	2.07	20.5	0.08	32.0	2.15
38.0	1.91	21.5	0.08	33.0	2.13
39.0	1.84	23.5	0.17	35.0	2.08
44.0	1.64	25.5	0.32	39.0	1.93
49.0	1.47	26.5	0.28	42.0	1.90
49.5	1.46	29.0	0.20	44.0	1.21
55.0	1.56	29.5	0.26	45.0	1.29
59.0	1.45	34.0	0.64	47.0	1.43
60.0	1.42	34.5	0.62	48.0	1.40
71.0	1.12	44.5	0.11	52.5	1.27
79.0	0.97	51.5	0.08	53.0	1.30
80.0	0.96	54.5	0.01	62.0	1.53
85.0	0.79	62.0	-0.12	63.0	1.51
89.5	0.65	64.5	-0.07	67.0	1.42
95.5	0.81	65.5	-0.04	68.0	1.37
99.0	0.81	74.0	0.26	72.0	1.13
99.5	0.80	74.5	0.22	73.0	1.10
104.0	0.77	84.0	-0.02	81.0	0.95
112.0	0.62	84.5	-0.02	83.0	1.02
116.5	0.67	95.0	0.11	84.0	1.05
118.5	0.70	98.5	0.13	90.0	0.87
		104.5	0.21	93.0	0.83
		107.0	0.26	101.0	0.72
				103.0	0.78
				106.0	0.87
				113.0	0.62
				117.0	0.61
				119.0	0.68

Table 13.--*Infiltration rate as a function of time in different runs*--Continued

LUALUALEI SOIL--Continued

SITE 21 PLOT 1-WET TIME, MIN	SITE 21 PLOT 1-WET INFILT. RATE, IN/HR	SITE 22 PLOT 2-DRY TIME, MIN	SITE 22 PLOT 2-DRY INFILT. RATE, IN/HR
5.5	2.56	15.0	2.40
6.5	2.31	16.0	2.34
7.5	2.25	17.0	2.33
8.5	2.13	18.0	2.31
10.0	1.61	19.0	2.30
10.5	1.49	20.0	2.28
12.0	0.83	21.0	2.25
12.5	0.90	22.0	2.19
14.5	1.09	23.0	2.05
15.5	1.06	23.5	2.06
18.5	0.96	24.0	2.05
20.0	0.91	25.0	2.04
21.5	0.85	29.0	1.96
24.5	0.72	30.0	1.94
25.0	0.70	32.0	1.51
27.5	0.59	32.5	1.25
29.5	0.49	34.0	1.35
30.5	0.55	35.0	1.33
35.5	0.83	37.0	1.25
36.0	0.85	38.0	1.23
45.5	0.53	41.0	1.15
46.5	0.51	42.0	1.13
50.5	0.78	46.0	1.04
55.5	0.64	47.0	1.00
56.5	0.63	56.0	0.83
65.0	0.24	57.0	0.81
65.5	0.22	60.5	0.86
67.0	0.13	62.0	0.82
75.5	0.59	66.0	0.74
76.5	0.64	67.0	0.74
83.5	0.18	73.0	0.75
85.5	0.32	77.0	0.68
87.5	0.44	79.0	0.61
95.5	0.49	82.0	0.52
96.5	0.50	87.0	0.41
101.5	0.53	88.0	0.39
105.5	0.36	94.5	0.43
107.0	0.31	97.0	0.51
113.5	0.27	100.0	0.60
115.5	0.26	106.0	0.55
117.0	0.25	107.0	0.54
		114.5	0.35
		117.0	0.39
		118.0	0.41

Table 13.--*Infiltration rate as a function of time in different runs*--Continued

WAIKANE SOIL

SITE 23 PLOT 2-WET		SITE 24 PLOT 2-DRY		SITE 24 PLOT 2-WET	
TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR
48.0	2.51	60.0	2.64	2.0	2.65
49.0	2.49	61.0	2.62	3.0	2.52
50.0	2.49	63.0	2.61	4.5	2.32
51.0	2.49	64.0	2.59	5.0	2.28
53.0	2.49	65.0	2.59	6.5	2.13
55.0	2.49	67.0	2.58	7.0	2.09
55.5	2.49	68.0	2.57	9.0	1.92
57.0	2.48	69.0	2.57	9.5	1.88
58.0	2.48	70.0	2.56	11.0	1.82
60.0	2.48	72.0	2.54	11.5	1.80
61.0	2.48	73.0	2.53	12.0	1.80
62.5	2.48	76.0	2.51	14.0	1.82
64.0	2.48	77.0	2.50	15.0	1.79
65.0	2.48	79.0	2.48	17.0	1.71
67.0	2.48	82.0	2.45	18.0	1.71
70.0	2.48	85.0	2.43	21.0	1.73
73.0	2.48	86.0	2.43	23.0	1.75
73.5	2.48	90.0	2.35	24.0	1.73
76.0	2.47	92.0	2.28	27.0	1.65
78.0	2.48	97.0	2.29	28.0	1.63
80.0	2.48	100.0	2.27	32.0	1.63
85.0	2.47	102.0	2.26	33.0	1.63
88.0	2.47	105.0	2.20	42.0	1.63
90.0	2.47	107.0	2.16	43.0	1.63
94.0	2.47	110.0	2.17	47.0	1.59
96.0	2.47	111.0	2.17	48.0	1.57
98.0	2.47	115.0	2.00	52.0	1.58
100.0	2.46	120.0	1.99	53.0	1.58
106.0	2.46			62.0	1.51
108.0	2.46			68.0	1.46
110.0	2.46			72.0	1.29
118.0	2.45			73.0	1.25
120.0	2.45			78.0	1.41
128.0	2.45			82.0	1.26
130.0	2.45			84.0	1.18
138.0	2.44			90.0	1.24
140.0	2.43			92.0	1.24
148.0	2.43			96.0	1.29
150.0	2.43			102.0	1.31
158.0	2.42			108.0	1.30
160.0	2.42			117.0	1.27
169.0	2.39				
171.0	2.38				
176.0	2.38				
178.0	2.39				

Table 13.--*Infiltration rate as a function of time in different runs*--Continued

WAIKANE SOIL--Continued

SITE 25 PLOT 1-DRY TIME, MIN	SITE 25 PLOT 1-DRY INFILT. RATE, IN/HR	SITE 25 PLOT 1-WET TIME, MIN	SITE 25 PLOT 1-WET INFILT. RATE, IN/HR
82.0	2.43	12.0	2.47
83.0	2.32	13.0	2.42
85.0	2.28	15.0	2.41
87.0	2.24	17.0	2.41
89.0	2.20	19.0	2.39
91.0	2.05	21.0	2.36
92.0	2.01	22.0	2.34
94.0	1.86	25.0	2.20
95.0	1.82	26.0	1.75
97.0	1.71	28.0	1.65
98.0	1.67	31.0	1.42
100.0	1.58	33.0	1.18
101.0	1.56	34.0	1.14
104.0	1.51	37.0	1.05
105.0	1.49	39.0	1.00
107.0	1.39	42.0	1.02
108.0	1.46	46.0	1.04
111.0	1.48	52.0	1.08
112.0	1.50	57.0	1.10
115.0	1.58	59.0	1.12
122.0	1.49	62.0	1.10
		64.0	1.09
		70.0	1.17
		72.0	1.17
		75.0	1.17
		80.0	1.15
		82.0	1.13
		85.0	1.10
		90.0	1.14
		92.0	1.17
		95.0	1.19
		100.0	1.17
		102.0	1.13
		105.0	1.08
		112.0	1.15
		114.0	1.18
		119.0	1.15

Table 13.--*Infiltration rate as a function of time in different runs*--Continued

KUKAIAU SOIL

SITE 26 PLOT 1-DRY		SITE 26 PLOT 2-DRY		SITE 27 PLOT 1-DRY		SITE 27 PLOT 2-DRY	
TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR
37.0	2.74	25.0	2.71	17.0	2.74	19.0	2.84
39.0	2.33	26.0	2.66	18.0	2.54	20.0	2.66
40.0	2.66	28.0	2.63	20.0	2.50	21.0	2.64
42.0	2.66	30.0	2.57	22.0	2.46	24.0	2.51
43.0	2.66	32.0	2.58	25.0	2.33	26.0	2.39
44.0	2.64	34.0	2.52	26.0	2.28	27.5	2.19
46.0	2.63	35.0	2.48	29.0	2.00	28.0	2.18
47.0	2.60	38.0	2.44	30.0	1.95	29.0	2.14
50.0	2.55	41.0	2.38	35.0	1.62	30.0	2.09
53.0	2.54	44.0	2.26	36.0	1.61	32.0	1.87
56.0	2.55	45.0	2.20	40.0	1.58	33.0	1.71
59.0	2.56	47.0	2.17	42.0	1.56	35.0	1.60
62.0	2.48	50.0	2.13	52.0	1.41	38.0	1.39
66.0	2.06	53.0	2.08	61.0	1.28	41.0	1.35
67.0	2.05	55.0	2.13	71.0	0.95	42.0	1.35
72.0	2.00	59.0	2.20	83.0	0.91	44.0	1.32
77.0	1.96	65.0	1.95	88.0	0.88	46.5	1.28
79.0	1.95	68.0	1.72	89.0	0.90	53.0	0.94
82.0	1.92	70.0	1.62	97.0	1.02	59.0	0.94
84.0	1.90	73.0	1.43	99.0	1.04	61.0	0.93
87.0	1.85	75.0	1.41	109.0	1.16	72.0	0.67
90.0	1.79	82.0	1.32			75.0	0.59
97.0	1.73	85.0	1.47			77.0	0.63
107.0	1.68	87.0	1.54			81.0	0.77
109.0	1.67	94.0	1.39			87.0	0.75
117.0	0.88	95.0	1.40			97.0	0.72
118.0	0.66	102.0	1.46			100.0	0.69
		105.0	1.41				
		111.0	1.29				
		118.0	1.59				

Table 13.--*Infiltration rate as a function of time in different runs*--Continued

KUKAIAU SOIL--Continued

SITE 28 PLOT 1-DRY		SITE 28 PLOT 2-DRY		SITE 29 PLOT 1-DRY		SITE 29 PLOT 2-DRY	
TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR
10.0	2.31	12.0	2.46	26.0	1.99	20.0	2.48
13.0	2.23	15.0	2.34	27.0	1.89	21.0	2.44
15.0	2.20	17.0	2.27	29.0	1.88	23.0	2.43
19.0	2.04	18.0	2.17	30.0	1.86	25.0	2.41
20.0	2.01	20.5	2.09	31.0	1.85	27.0	2.37
23.0	1.92	21.0	2.08	33.0	1.81	30.0	2.29
26.0	1.84	22.0	2.05	35.0	1.73	30.5	2.26
27.0	1.80	25.0	1.96	36.0	1.65	33.0	2.21
32.0	1.74	26.0	1.91	42.0	1.54	36.0	2.12
33.0	1.72	28.0	1.89	43.0	1.51	38.0	2.01
35.0	1.66	28.5	1.89	45.0	1.44	39.0	1.97
36.0	1.65	32.0	1.68	48.0	1.24	44.5	1.58
40.0	1.55	34.0	1.66	49.0	1.14	45.0	1.58
41.0	1.52	37.0	1.62	53.0	0.91	48.5	1.57
51.0	1.28	38.5	1.61	54.0	0.83	50.0	1.58
54.0	1.29	42.0	1.63	59.0	1.17	57.5	1.64
56.0	1.30	44.0	1.64	63.0	1.13	60.0	1.60
59.0	1.38	50.0	1.44	72.0	1.00	65.0	1.48
61.0	1.43	52.0	1.41	73.0	0.98	70.0	1.33
65.0	1.42	57.0	1.31			71.5	1.28
69.0	1.30	58.0	1.29				
71.0	1.21	62.0	1.29				
79.0	1.19	63.0	1.30				
81.0	1.18	71.5	1.26				
89.0	1.06	72.0	1.26				
91.0	1.03	81.5	1.21				
97.0	1.13	92.0	1.14				
99.0	1.11	95.5	1.11				
101.0	1.09	101.5	1.22				
108.0	0.99	102.0	1.22				
113.0	0.97	109.0	1.20				
		112.0	1.15				
		112.5	1.14				

Table 13.--*Infiltration rate as a function of time in different runs*--Continued

KUKAIAU SOIL--Continued

SITE 30 PLOT 1-DRY		SITE 30 PLOT 2-DRY		SITE 30 PLOT 1-WET		SITE 30 PLOT 2-WET	
TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR
22.0	2.51	24.0	2.65	5.0	2.37	4.0	2.55
24.0	2.03	26.0	2.51	6.0	2.13	6.0	2.28
25.0	1.95	27.0	2.46	7.0	2.08	7.0	1.72
26.0	1.86	28.0	2.38	10.0	1.72	9.0	1.50
27.0	1.83	29.0	2.33	11.0	1.23	10.0	1.34
29.0	1.76	31.0	2.20	12.0	1.17	11.0	1.27
30.0	1.73	31.5	2.15	14.0	1.03	12.0	1.21
31.0	1.71	34.0	1.98	15.0	1.04	13.0	1.18
35.0	1.54	35.0	1.88	17.0	1.06	14.0	1.16
38.0	1.38	37.0	1.84	19.0	1.00	15.0	1.14
39.0	1.33	40.0	1.79	21.0	0.94	17.0	1.08
41.0	1.37	41.0	1.76	22.0	0.91	18.0	1.05
44.0	1.42	43.0	1.76	24.0	0.88	21.0	1.09
45.0	1.45	46.0	1.74	25.0	0.85	23.0	1.04
47.0	1.49	48.5	1.73	27.0	0.94	24.0	0.99
48.0	1.50	49.0	1.74	28.0	0.98	26.0	1.05
52.0	1.65	50.0	1.74	30.0	0.92	27.0	1.08
53.0	1.63	54.0	1.61	32.0	0.86	29.0	1.05
58.0	1.55	56.0	1.54	35.0	0.88	30.0	1.04
62.0	1.51	63.0	1.47	37.0	0.89	34.0	0.93
67.0	1.46	64.0	1.48	42.0	0.86	35.0	0.90
72.0	1.40	68.0	1.48	45.0	0.82	41.5	0.83
81.0	1.27	69.0	1.47	49.0	0.76	44.0	0.80
82.0	1.23	74.0	1.39	50.0	0.71	49.0	0.75
85.0	1.12	82.0	1.25	52.0	0.60	51.0	0.74
93.0	1.07	89.0	1.30	56.0	0.69	55.0	0.79
99.0	0.97	94.0	1.25				
		97.0	1.22				

Table 13.--*Infiltration rate as a function of time in different runs*--Continued

KUKAIAU SOIL--Continued

SITE 31 PLOT 1-DRY		SITE 31 PLOT 2-DRY		SITE 32 PLOT 1-DRY		SITE 32 PLOT 2-DRY	
TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR
17.0	2.34	12.0	2.40	10.0	2.29	10.0	2.69
18.0	2.24	14.0	2.28	12.0	2.19	12.0	2.38
19.0	2.21	15.0	2.26	13.0	2.16	13.0	2.30
21.0	2.10	16.0	2.20	15.0	2.07	14.5	1.96
22.0	2.07	17.0	2.16	16.0	2.03	15.0	1.93
23.0	2.04	18.5	2.03	17.0	1.95	17.5	1.66
24.0	2.01	21.0	1.85	18.0	1.89	19.0	1.57
26.0	1.92	21.5	1.80	20.0	1.79	19.5	1.54
27.0	1.86	22.0	1.79	21.0	1.72	20.0	1.52
29.0	1.64	25.0	1.70	22.0	1.62	21.0	1.46
30.0	1.63	28.0	1.59	25.0	1.44	23.0	1.39
34.0	1.57	29.5	1.52	27.0	1.38	24.0	1.35
36.0	1.54	31.0	1.49	28.0	1.35	27.0	1.15
39.0	1.50	35.0	1.43	30.0	1.33	29.0	1.16
40.0	1.48	37.0	1.43	31.0	1.32	30.0	1.15
42.0	1.38	39.5	1.43	33.0	1.30	32.0	1.06
43.0	1.31	42.0	1.34	34.0	1.29	33.0	1.01
47.0	1.32	43.0	1.30	36.0	1.15	35.0	1.06
50.0	1.32	48.0	1.28	37.0	1.07	36.0	1.07
54.0	1.24	52.0	1.24	41.0	1.15	40.0	0.98
57.0	1.12	53.0	1.23	42.0	1.17	41.0	0.95
59.0	0.99	57.0	1.16	43.0	-0.17	48.0	1.01
66.0	0.96	58.0	1.15	44.0	0.96	50.0	0.96
67.0	0.93	66.0	1.15	47.0	1.00	51.0	0.94
68.0	0.89	67.0	1.06	50.0	1.05	55.0	0.83
70.0	0.96	68.0	0.95	51.0	1.08	56.0	0.79
				53.0	1.13	60.0	0.89
				56.0	0.97	61.0	0.92
				62.0	0.97	70.0	0.96
				64.0	0.97	79.0	0.83
				70.0	0.96	80.0	0.80
				74.0	0.92	82.0	0.74
				78.0	1.39	88.0	0.81
				80.0	0.93	94.0	0.71
				83.0	0.79	10.0	0.63
				84.0	0.83	101.0	0.63
				88.0	0.95	110.0	0.42
				93.0	0.86	111.0	0.39
				94.0	0.85	117.0	0.46
				98.0	0.79		
				102.0	0.64		
				104.0	0.70		
				107.0	0.78		
				109.0	0.81		
				112.0	0.98		
				116.0	0.87		
				120.0	0.89		

Table 13.--*Infiltration rate as a function of time in different runs*--Continued

KUKAIAU SOIL--Continued

SITE 33 PLOT 1-DRY		SITE 33 PLOT 2-DRY		SITE 33 PLOT 1-WET		SITE 33 PLOT 2-WET	
TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR
39.0	2.44	38.0	2.49	4.0	2.45	3.0	2.59
40.0	2.30	39.0	2.37	5.0	1.99	5.0	2.03
42.0	2.28	40.0	2.37	6.0	1.52	6.0	1.86
43.0	2.26	42.0	2.36	7.0	1.22	6.5	1.69
44.0	2.23	43.0	2.34	9.0	1.02	8.0	1.39
45.0	2.21	44.0	2.32	11.0	0.97	8.5	1.22
47.0	2.14	45.0	2.33	12.0	0.95	10.0	1.19
48.0	2.10	46.0	2.34	14.0	0.91	11.0	1.16
49.0	2.06	47.0	2.30	15.0	0.89	12.0	1.15
52.0	2.05	48.0	2.26	17.0	0.91	13.0	1.13
53.0	2.05	51.0	2.21	20.0	0.96	14.0	1.11
57.0	1.99	52.0	2.19	23.0	0.91	16.0	1.11
58.0	1.98	54.0	2.17	26.0	0.85	17.0	1.10
61.0	1.96	55.0	2.17	27.0	0.83	20.0	1.09
62.0	1.95	57.0	2.13	29.0	0.82	22.0	1.10
64.0	1.90	58.0	2.10	30.0	0.81	23.0	1.11
67.0	1.80	61.0	2.07	32.0	0.77	25.0	1.06
69.0	1.83	63.0	2.04	34.0	0.74	26.0	1.03
70.0	1.85	65.0	2.01	35.0	0.74	28.0	1.03
73.0	1.90	68.0	1.95	38.0	0.79	29.0	1.03
78.0	1.60	69.0	1.93	42.0	0.80	32.0	1.00
79.0	1.58	77.0	1.94	44.0	0.78	33.0	0.99
81.0	1.53	78.0	1.88	45.0	0.77	36.0	0.98
84.0	1.54	79.0	1.79	48.0	0.78	40.0	1.01
85.0	1.54	83.0	1.76	52.0	0.77	43.0	1.01
89.0	1.52	84.0	1.75	54.0	0.81	44.5	1.03
90.0	1.52	88.0	1.70	55.0	0.84	48.0	1.03
95.0	1.48	90.0	1.69	59.0	0.81	49.0	1.03
103.0	1.45	103.0	1.65	62.0	0.81	53.0	1.01
109.0	1.36	108.0	1.59	64.0	0.83	54.0	1.00
111.0	1.33	109.0	1.58	65.0	0.84	61.0	1.07
115.0	1.22	114.0	1.43	71.0	0.88	63.0	1.04
118.0	1.32	117.0	1.50	74.0	0.90	65.0	1.00
119.0	1.22	118.0	1.47	75.0	0.91	72.0	1.02
		119.0	1.44	78.0	0.90	73.0	1.03
				84.0	0.85	79.0	1.13
				89.0	0.81	85.0	1.04
				93.0	0.76	86.0	1.02
				94.0	0.83	88.0	0.95
				97.0	1.03	96.0	0.90
						98.0	1.14

Table 13.--*Infiltration rate as a function of time in different runs*--Continued

HILO SOIL

SITE 34 PLOT 1-DRY TIME, MIN	SITE 34 PLOT 1-DRY INFILT. RATE, IN/HR	SITE 34 PLOT 2-DRY TIME, MIN	SITE 34 PLOT 2-DRY INFILT. RATE, IN/HR	SITE 34 PLOT 1-WET TIME, MIN	SITE 34 PLOT 1-WET INFILT. RATE, IN/HR	SITE 34 PLOT 2-WET TIME, MIN	SITE 34 PLOT 2-WET INFILT. RATE, IN/HR
18.0	2.46	19.0	2.76	7.0	2.35	7.0	3.17
19.0	1.89	20.0	1.79	10.0	1.50	9.0	2.93
21.0	1.71	21.0	1.68	11.0	0.51	10.0	2.78
24.0	1.04	22.0	1.53	12.0	0.47	10.5	2.54
25.0	0.89	23.5	1.15	13.0	0.41	12.0	1.94
26.0	0.65	25.5	1.10	14.0	0.39	12.5	1.37
27.0	0.60	26.0	1.04	17.0	0.39	15.5	0.76
28.0	0.57	27.5	0.88	20.0	0.28	16.0	0.77
29.0	0.56	29.0	0.84	23.0	0.30	17.0	0.76
31.0	0.57	31.0	0.81	24.0	0.30	18.0	0.76
33.0	0.57	32.0	0.85	26.0	0.29	22.0	0.63
34.0	0.52	34.0	0.91	27.0	0.29	23.0	0.56
36.0	0.41	35.0	0.88	29.0	0.27	26.0	0.38
39.0	0.37	38.0	0.80	30.0	0.26	27.0	0.34
40.0	0.39	39.0	0.78	32.0	0.28	29.0	0.38
42.0	0.42	43.0	0.58	33.0	0.29	31.0	0.40
43.0	0.41	44.0	0.64	36.0	0.25	36.0	0.53
46.0	0.40	47.0	0.83	37.0	0.27	37.0	0.50
48.0	0.39	49.0	0.77	39.0	0.30	40.0	0.46
50.0	0.38	53.0	0.67	42.0	0.39	45.0	0.57
55.0	0.43	58.0	0.55	45.0	0.28	47.0	0.51
58.0	0.40	59.0	0.56	48.0	0.22	51.0	0.44
59.0	0.39	64.0	0.61	52.0	0.24	52.0	0.44
64.0	0.41	65.0	0.62	53.0	0.24	56.0	0.44
68.0	0.36	67.5	0.58	57.0	0.27	57.0	0.46
69.0	0.35	69.0	0.60	58.0	0.28	63.0	0.50
74.0	0.39	78.0	0.73	65.0	0.32	67.0	0.38
78.0	0.38	79.0	0.72	67.0	0.29	72.0	0.20
79.0	0.38	89.0	0.64	70.0	0.24	79.0	0.33
87.0	0.37	90.5	0.65	75.0	0.31	87.0	0.48
88.0	0.34	97.0	0.62	77.0	0.31	89.0	0.54
89.0	0.30	99.0	0.55	80.0	0.29	97.0	0.39
94.0	0.21	105.0	0.38	85.0	0.22	98.0	0.34
98.0	0.25	109.0	0.52	87.0	0.23	107.0	0.43
99.0	0.26	111.0	0.58	90.0	0.25	108.0	0.46
104.0	0.26	118.0	0.44	95.0	0.29		
107.0	0.24	119.0	0.41	97.0	0.26		
112.0	0.26			101.0	0.21		
117.0	0.21			105.0	0.25		
118.0	0.69						

Table 13.--*Infiltration rate as a function of time in different runs*--Continued

HILO SOIL--Continued

SITE 35 PLOT 1-DRY TIME, MIN	SITE 35 PLOT 1-DRY INFILT. RATE, IN/HR	SITE 35 PLOT 2-DRY TIME, MIN	SITE 35 PLOT 2-DRY INFILT. RATE, IN/HR
10.0	2.57	8.0	2.60
13.0	0.80	9.0	2.45
14.0	0.78	11.0	2.34
15.0	0.75	13.0	1.73
17.0	0.69	15.0	1.24
19.0	0.63	16.0	0.79
22.0	0.67	17.0	0.76
23.0	0.63	18.0	0.73
25.0	0.56	21.0	0.64
29.0	0.53	22.0	0.59
28.0	0.46	25.0	0.41
29.0	0.44	27.0	0.37
31.0	0.41	28.0	0.35
32.0	0.37	30.0	0.26
34.0	0.28	32.0	0.18
35.0	0.25	33.0	0.20
40.0	0.20	37.0	0.22
47.0	0.28	38.0	0.20
50.0	0.33	43.0	0.17
51.0	0.35	49.0	0.28
58.0	0.26	53.0	0.21
60.0	0.23	54.0	0.19
63.0	0.17	57.0	0.13
70.0	0.17		
75.0	-0.09		
80.0	0.06		
82.0	0.12		
88.0	0.10		
90.0	0.08		
100.0	0.04		

Table 13.--*Infiltration rate as a function of time in different runs*--Continued

KAWAIHAE SOIL

SITE 36 PLOT 1-DRY TIME, MIN	SITE 36 PLOT 1-DRY INFILT. RATE, IN/HR	SITE 36 PLOT 2-DRY TIME, MIN	SITE 36 PLOT 2-DRY INFILT. RATE, IN/HR	SITE 36 PLOT 1-WET TIME, MIN	SITE 36 PLOT 1-WET INFILT. RATE, IN/HR	SITE 36 PLOT 2-WET TIME, MIN	SITE 36 PLOT 2-WET INFILT. RATE, IN/HR
9.0	2.39	16.0	2.53	2.0	2.35	2.0	2.43
10.0	2.22	17.0	2.46	4.0	1.41	3.0	1.48
12.0	2.17	19.0	2.43	5.0	1.14	4.5	1.37
13.0	2.14	22.0	2.32	7.0	1.12	5.0	1.32
16.0	1.95	23.0	2.29	8.0	1.10	7.0	1.08
18.0	1.73	25.0	2.21	10.0	0.98	8.5	1.22
19.0	1.58	26.0	2.15	11.0	0.98	9.0	1.20
22.0	1.29	27.5	1.99	12.0	0.97	11.0	1.14
24.0	1.22	29.0	1.90	13.0	0.97	12.0	0.97
25.0	1.29	31.0	1.72	15.0	0.97	13.0	0.73
26.0	1.35	35.0	1.68	16.0	0.97	15.0	0.89
28.0	1.26	37.0	1.67	18.0	0.95	16.0	0.96
29.0	1.20	38.0	1.63	20.0	0.92	17.0	0.96
31.0	1.11	41.0	1.48	21.0	0.92	18.0	1.05
32.0	1.06	42.5	1.39	23.0	0.92	19.0	1.12
35.0	1.02	46.0	1.40	24.0	0.93	22.0	0.81
39.0	0.99	56.0	1.46	26.0	0.93	24.0	0.86
40.0	0.98	57.5	1.46	27.0	0.91	25.0	0.89
49.0	0.93	61.0	1.38	30.0	0.89	27.0	0.96
50.0	0.93	63.0	1.33	32.0	0.91	28.0	0.98
54.0	0.90	72.0	1.38	35.0	0.94	32.0	1.00
56.0	0.88	76.0	1.17	38.0	1.04	33.0	1.00
59.0	0.88	83.0	1.22	41.0	0.83	39.0	0.69
60.0	0.89	86.0	1.16	43.0	0.75	42.0	0.74
65.0	0.83	91.0	1.07	47.0	0.76	43.0	0.76
71.0	0.71	96.0	1.01	48.0	0.76	47.0	0.77
79.0	0.76	97.0	0.99	52.0	0.79	48.0	0.77
80.0	0.77	106.0	0.80	53.0	0.80	52.0	0.91
89.0	0.69	108.0	0.73	55.0	0.79	53.0	0.94
90.0	0.69	117.0	0.75	58.0	0.70	58.0	0.83
93.0	0.44	119.0	0.68	61.0	0.76	61.0	0.58
97.0	0.60			62.0	0.73	62.0	0.55
99.0	0.54			65.0	0.67	65.0	0.51
100.0	0.50			69.0	0.65	70.0	0.79
105.0	0.50			72.0	0.64	74.0	0.76
108.0	0.83			73.0	0.64	79.0	0.58
110.0	0.91			77.0	0.70	82.0	0.63
114.0	0.53			81.0	0.69	89.0	0.76
115.0	0.54			82.0	0.68	92.0	0.80
				85.0	0.62		
				89.0	0.67		
				92.0	0.72		

Table 13.--*Infiltration rate as a function of time in different runs*--Continued

KAWAIHAE SOIL--Continued

SITE 37 PLOT 1-DRY TIME, MIN	SITE 37 PLOT 1-DRY INFILT. RATE, IN/HR	SITE 37 PLOT 2-DRY TIME, MIN	SITE 37 PLOT 2-DRY INFILT. RATE, IN/HR	SITE 38 PLOT 1-DRY TIME, MIN	SITE 38 PLOT 1-DRY INFILT. RATE, IN/HR	SITE 38 PLOT 2-DRY TIME, MIN	SITE 38 PLOT 2-DRY INFILT. RATE, IN/HR
18.0	2.35	18.0	2.40	12.0	2.50	10.0	2.41
20.0	2.12	19.0	2.34	13.0	2.44	11.0	2.22
21.0	2.06	20.0	2.32	15.0	2.38	12.0	2.17
23.0	1.80	22.0	2.26	16.0	2.23	15.0	1.63
27.0	1.77	23.0	2.21	17.0	2.17	17.0	1.45
28.0	1.75	25.0	2.11	19.0	1.83	19.0	1.22
31.0	1.68	26.0	1.93	21.0	1.73	22.0	1.11
34.0	1.60	27.0	1.90	22.0	1.67	23.0	1.05
37.0	1.10	28.0	1.86	23.0	1.59	26.0	0.85
40.0	1.13	31.0	1.70	25.0	1.49	27.0	0.78
41.0	1.14	32.0	1.63	27.0	1.36	29.0	0.66
43.0	1.11	34.0	1.49	28.0	1.33	30.0	0.61
46.0	1.08	37.0	1.23	31.0	1.24	32.0	0.47
48.0	1.05	40.0	1.31	32.0	1.21	33.0	0.37
51.0	0.99	43.0	1.24	36.0	1.16	35.0	0.69
		44.0	0.03	37.0	1.15	36.0	0.80
				41.0	1.08	40.0	0.64
				42.0	1.05	41.0	0.57
				48.0	0.87	49.0	0.15
				52.0	0.84	50.0	0.17
				53.0	0.83	55.0	0.15
				57.0	0.90	56.0	0.15
				58.0	0.91	61.0	0.57
				62.0	0.77	70.0	0.62
				70.0	0.94	71.0	0.62
				79.0	0.53	80.0	0.29
				82.0	0.57	81.0	0.25
				83.0	0.60	87.0	0.25
				87.0	0.74	90.0	0.07
				92.0	0.72	92.0	-0.08
				93.0	0.72	95.0	0.10
				95.0	0.39	100.0	0.05
				100.0	0.56	101.0	0.03
				102.0	0.45	106.0	0.31
				103.0	0.40	114.0	0.08
				107.0	0.71	118.0	0.30
				112.0	0.53		
				113.0	0.53		
				118.0	0.65		

Table 13.--*Infiltration rate as a function of time in different runs*--Continued

KAWAIHAE SOIL--Continued

SITE 38 PLOT 1-WET TIME, MIN	SITE 38 PLOT 1-WET INFILT. RATE, IN/HR	SITE 38 PLOT 2-WET TIME, MIN	SITE 38 PLOT 2-WET INFILT. RATE, IN/HR
2.0	2.40	1.0	2.43
4.0	1.24	3.0	1.22
5.0	1.21	4.0	1.06
7.0	1.11	5.0	0.84
9.0	0.96	6.0	0.77
10.0	0.89	7.0	0.69
11.0	0.82	8.0	0.62
12.0	0.75	9.0	0.55
15.0	0.54	11.0	0.57
18.0	0.29	12.0	0.58
22.0	0.35	14.0	0.50
24.0	0.37	17.0	0.35
25.0	0.38	20.0	0.44
27.0	0.46	23.0	0.52
30.0	0.57	26.0	0.44
32.0	0.50	27.0	0.42
35.0	0.36	31.0	0.51
41.0	0.14	32.0	0.54
42.0	0.12	39.0	0.34
45.0	0.05	41.0	0.40
51.0	0.69	44.0	0.49
52.0	0.60	49.0	0.41
56.0	0.15	51.0	0.42
61.0	0.28	59.0	0.45
62.0	0.36	61.0	0.38
66.0	0.60	63.0	0.30
71.0	0.25	71.0	0.29
72.0	0.36	73.0	0.28
76.0	0.71	81.0	0.54
82.0	0.88	87.0	0.36
83.0	0.73	91.0	0.45
84.0	0.55	100.0	0.49
89.0	0.27	101.0	0.48
92.0	0.24	110.0	0.40
94.0	0.21		
99.0	0.15		
102.0	0.22		
104.0	0.28		
109.0	0.25		
112.0	0.29		

Table 13.--*Infiltration rate as a function of time in different runs*--Continued

NAALEHU SOIL

SITE 39 PLOT 1-DRY		SITE 39 PLOT 2-DRY		SITE 40 PLOT 1-DRY		SITE 40 PLOT 2-DRY	
TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR
20.0	2.75	15.0	2.43	29.0	2.44	10.0	2.44
21.0	2.21	16.0	2.25	30.0	2.17	13.0	2.24
25.0	1.99	17.0	2.22	33.0	2.10	15.0	2.11
27.0	1.90	18.0	2.19	34.0	2.08	17.5	1.81
29.0	1.75	19.0	2.15	36.0	2.00	19.0	1.70
30.0	1.65	20.0	2.10	39.0	1.78	20.0	1.61
33.0	1.50	21.0	2.05	40.0	1.65	21.0	1.50
36.0	1.27	23.0	1.94	42.0	1.48	23.0	1.57
37.0	1.13	24.0	1.88	44.0	1.21	24.0	1.34
39.0	1.19	25.0	1.82	45.0	1.19	26.0	1.24
42.0	0.99	26.0	1.77	48.0	1.10	27.0	1.17
44.0	0.79	28.0	1.69	49.0	1.06	29.0	1.17
49.0	0.74	31.0	1.53	54.0	0.87	31.0	1.17
50.0	0.74	34.0	1.26	59.0	0.89	35.0	0.93
54.0	0.73	35.0	1.16	64.0	0.84	36.0	0.86
59.0	0.76	39.0	1.17	69.0	0.57	40.0	0.87
60.0	0.72	40.0	1.11	74.0	0.58	41.0	0.88
64.0	0.55	43.0	1.07	79.0	0.64	46.0	0.81
65.0	0.55	44.0	1.05	84.0	0.89	50.0	0.87
67.0	0.54	49.0	0.93	89.0	0.59	51.0	0.88
70.0	0.60	53.0	0.90	94.0	0.53	55.0	0.81
72.0	0.64	55.0	0.88	99.0	0.45	56.0	0.79
77.0	0.68	58.0	0.81	104.0	0.45	60.0	0.80
82.0	0.30	63.0	0.73	109.0	0.56	61.0	0.80
87.0	0.37	68.0	0.67	115.0	0.69	70.0	0.71
90.0	0.46	72.0	0.66	119.0	0.53	72.0	0.70
97.0	0.64	73.0	0.64			76.0	0.66
100.0	0.51	84.0	0.50			80.0	0.66
102.0	0.39	91.0	0.57			81.0	0.66
107.0	0.49	93.0	0.58			86.0	0.74
110.0	0.47	95.0	0.54			90.0	0.67
112.0	0.47	101.0	0.41			91.0	0.66
117.0	0.57	105.0	0.47			97.0	0.51
120.0	1.67	106.0	0.48			100.0	0.56
		117.0	0.52			106.0	0.65
						111.0	0.46
						119.0	0.48

Table 13.--*Infiltration rate as a function of time in different runs*--Continued

NAALEHU SOIL--Continued

SITE 40 PLOT 1-WET		SITE 40 PLOT 2-WET	
TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR
1.0	2.47	1.0	2.44
2.0	0.88	2.0	0.72
4.0	0.71	3.5	0.63
6.0	0.53	4.0	0.67
7.0	0.42	6.0	0.48
8.0	0.39	8.0	0.37
10.0	0.33	8.5	0.34
13.0	0.17	10.0	0.18
14.0	0.17	10.5	0.12
17.0	0.15	13.0	0.28
20.0	0.30	14.0	0.28
21.0	0.33	16.0	0.27
25.0	0.28	17.0	0.28
26.0	0.28	20.0	0.35
30.0	0.26	21.5	0.38
31.0	0.30	23.0	0.37
35.0	0.41	24.5	0.36
40.0	0.24	26.0	0.33
41.0	0.30	28.5	0.29
47.0	0.55	31.0	0.34
51.0	0.41	34.0	0.39
56.0	0.52	39.0	0.35
61.0	0.35	46.0	0.46
66.0	0.35	47.0	0.48
71.0	0.40	50.0	0.38
76.0	0.20	51.0	0.39
81.0	0.16	57.0	0.44
86.0	0.46	61.0	0.37
91.0	0.34	62.0	0.35
98.0	0.18	71.0	0.33
101.0	0.43	72.0	0.30
106.0	0.20	79.0	0.33
112.0	0.32	81.0	0.27
116.0	0.11	85.0	0.14
120.0	0.43	92.0	0.25
		99.0	0.49
		101.0	0.43
		109.0	0.13
		116.0	0.34

Table 13.--*Infiltration rate as a function of time in different runs*--Continued

PAKINI SOIL

SITE 41 PLOT 1-DRY		SITE 41 PLOT 2-DRY		SITE 42 PLOT 1-DRY		SITE 42 PLOT 2-DRY	
TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR	TIME, MIN	INFILT. RATE, IN/HR
10.0	2.63	11.0	2.70	10.0	2.73	9.0	2.70
11.0	2.49	12.0	2.61	13.0	2.17	10.0	2.48
13.0	2.45	14.0	2.52	15.0	2.08	12.0	2.37
14.0	2.42	16.0	2.03	17.0	1.98	15.0	1.65
15.0	2.38	18.0	2.10	19.0	1.85	16.0	1.62
17.0	2.22	20.0	2.06	20.0	1.76	18.0	1.55
19.0	2.11	23.0	1.85	23.0	1.68	19.0	1.50
20.0	2.02	24.0	1.82	25.0	1.63	21.0	1.41
22.0	1.96	26.0	1.75	29.0	1.81	22.0	1.46
23.0	1.89	27.0	1.73	30.0	1.85	28.0	1.65
25.0	1.73	29.0	1.67	32.0	1.84	31.0	1.57
26.0	1.70	30.0	1.66	35.0	1.83	32.0	1.55
29.0	1.60	33.0	1.65	36.0	1.82	34.0	1.56
30.0	1.55	35.0	1.65	40.0	1.64	39.0	1.60
32.0	1.57	36.0	1.54	41.0	1.59	40.0	1.61
35.0	1.60	38.0	1.16	46.0	1.63	45.0	1.53
40.0	1.46	41.0	1.18	51.0	1.21	50.0	1.37
45.0	1.29	42.0	1.20	55.0	1.27	54.0	1.28
51.0	1.35	50.0	1.72	56.0	1.30	55.0	1.26
52.0	1.37	51.0	1.58	60.0	0.74	59.0	1.25
55.0	1.29	52.0	1.30	61.0	0.55	63.0	1.25
56.0	1.27	56.0	1.25	70.0	1.01	69.0	1.50
60.0	1.23	57.0	1.24	71.0	1.05	73.0	1.61
61.0	1.21	61.0	0.98	76.0	1.37	76.0	1.17
70.0	1.14	62.0	0.88	80.0	1.33	79.0	1.16
81.0	1.23	71.0	0.91	81.0	1.31	87.0	1.12
82.0	1.24	72.0	0.92	86.0	1.06	89.0	1.16
87.0	1.04	82.0	1.39	90.0	1.26	96.0	1.28
91.0	1.11	83.0	1.42	91.0	1.31	99.0	1.28
92.0	1.14			96.0	1.31	102.0	1.28
				100.0	1.23	110.0	1.24
				101.0	1.21	116.0	1.23
				106.0	1.38	119.0	1.25
				112.0	1.09		
				115.0	1.20		
				119.0	1.41		

Table 13.--*Infiltration rate as a function of time in different runs*--Continued

PAKINI SOIL--Continued

SITE 42 PLOT 1-WET TIME, MIN	SITE 42 PLOT 1-WET INFILT. RATE, IN/HR	SITE 42 PLOT 2-WET TIME, MIN	SITE 42 PLOT 2-WET INFILT. RATE, IN/HR
8.0	2.60	7.0	2.64
11.0	1.75	8.0	2.16
12.0	1.65	10.0	1.97
13.0	1.52	12.0	1.47
15.0	1.12	16.0	1.15
17.0	0.98	17.0	1.08
18.0	0.89	19.0	0.91
20.0	0.70	20.0	0.95
21.0	0.80	24.0	1.10
24.0	1.02	26.0	1.07
25.0	1.07	28.0	1.03
27.0	1.07	29.0	1.02
30.0	1.06	32.0	0.95
33.0	0.96	33.0	0.94
35.0	0.87	37.0	0.93
38.0	0.79	38.0	0.92
40.0	0.74	45.0	0.85
45.0	0.99	47.0	0.84
48.0	0.87	53.0	0.83
50.0	0.79	57.0	0.79
53.0	0.88	58.0	0.79
55.0	0.94	67.0	0.85
60.0	0.75	68.0	0.86
65.0	0.83	77.0	0.80
68.0	0.61	78.0	0.79
70.0	0.43	87.0	0.81
76.0	0.54	88.0	0.81
78.0	0.49	97.0	0.84
80.0	0.45	98.0	0.85
85.0	0.52	108.0	0.80
88.0	0.65	118.0	0.86
90.0	0.76		
95.0	0.59		
98.0	0.60		
100.0	0.60		
105.0	0.50		
108.0	0.54		
110.0	0.57		
115.0	0.77		
119.0	0.73		

☆GPO 690-797-1976

U. S. DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH SERVICE
WESTERN REGION
2850 TELEGRAPH AVENUE
BERKELEY, CALIFORNIA 94705